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DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

FACILITIES MAINTENANCE STUDY
TEST PLAN

by

Melvin A. Schwartz

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PROPULSION AND AUXILIARY SYSTEMS DEPARTMENT
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Shipboard facilities maintenance, viz, cleaning and preservation, requires a considerable expenditure of manpower and material resources. Due to a number of interrelated problems and practices, facilities maintenance is not currently performed efficiently. Consequently, man-hour expenditures are excessive; ships' condition, cleanliness, and appearance deteriorate;

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20. Abstract (Cont)

morale and motivation are undermined; and cost to the Navy increases. Previous research in this area identified potential solutions and evaluated, in a limited fashion, their feasibility. The solutions fell into three classes: (1) Manpower and Management, (2) Training, and (3) Equipment and Materials. Conclusions reached during initial research indicated a full-scale test of solutions, or innovations, in an operational environment would resolve problems identified. This document is a plan for the full-scale evaluation of innovative facilities maintenance concepts, termed collectively the Facilities Maintenance System. The hypotheses of the planned investigation include: (1) a significant reduction in man-hours expended on facilities maintenance would be feasible; (2) cleanliness, appearance, and condition of ships would improve; and (3) facilities maintenance personnel would exhibit a greater degree of skill and knowledge, if the innovative system were implemented. This plan describes the problem, approach, facilities maintenance innovations, and the planned experiment.

(Author)

ADMINISTRATIVE INFORMATION

This test plan was developed by the Shipboard Manning and Automation Project Office, David W. Taylor Naval Ship Research and Development Center, Code 2784, under the supervision of LCDR D. Vetter, USN. The program administrator is Mr. A. Rubinstein, Naval Material Command (MAT 034), and the program monitor is Mr. J. Sejd, Naval Sea Systems Command (SEA 032). This plan was developed under Program Element 62757N in Task Area SF 55525-291 and was accomplished under Work Unit 2784-106. Ship support to this project has been assigned the project number K397. The principal author of this plan is Mr. M. A. Schwartz, Navy Personnel Research and Development Center, Code 311, who has been designated principal investigator for the study. Questions and comments should be addressed to:

Melvin A. Schwartz
David W. Taylor Naval Ship R&D Center
Code 2784
Annapolis, Maryland 21402
(301) 267-3625 or 2358.

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LIST OF ABBREVIATIONS

AO - operational availability

est - estimated

FM - facilities maintenance

FMJIC - facilities maintenance job information card

FMS - facilities maintenance system

IMS - information management system

Mgmnt - Management

MIM - manpower and information management

mm - millimeters

Mnpwr - Manpower

MSI - maintenance support index

MTBF - mean-time-between-failures

MTTR - mean-time-to-repair

SITREPS - situation reports

SOE - suit of equipment

TTI - training and technical information

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ABSTRACT

Shipboard facilities maintenance, viz, cleaning and preservation, requires a considerable expenditure of manpower and material resources. Due to a number of interrelated problems and practices, facilities maintenance is not currently performed efficiently. Consequently, man-hour expenditures are excessive; ships' condition, cleanliness, and appearance deteriorate; morale and motivation are undermined; and cost to the Navy increases.

Previous research in this area identified potential solutions and evaluated, in a limited fashion, their feasibility. The solutions fell into three classes: (1) Manpower and Management, (2) Training, and (3) Equipment and Materials. Conclusions reached during initial research indicated a full-scale test of solutions, or innovations, in an operational environment would resolve problems identified.

This document is a plan for the full-scale evaluation of innovative facilities maintenance concepts, termed collectively the Facilities Maintenance System. The hypotheses of the planned investigation include: (1) a significant reduction in man-hours expended on facilities maintenance would be feasible; (2) cleanliness, appearance, and condition of ships would improve; and (3) facilities maintenance personnel would exhibit a greater degree of skill and knowledge, if the innovative system were implemented.

This plan describes the problem, approach, facilities maintenance innovations, and the planned experiment.

INTRODUCTION

BACKGROUND

The Shipboard Manning and Automation Program was established by the Chief of Naval Material in response to a Chief of Naval Operations/Vice Chief of Naval Operations Action Sheet. A David W. Taylor Naval Ship Research and Development

Center letter promulgated the Task Area Plan for the Program. This is an exploratory development program (6.2) established to develop, demonstrate, and evaluate concepts for achieving reduction in shipboard manning while maintaining or improving ship readiness and operational effectiveness through automation, redesign, and use of new procedures. Earlier reports[1,2] describe initial testing of innovations in facilities maintenance which were designed to achieve this goal for surface ships and include recommendations for a follow-on testing effort. The following eight ships were assigned as demonstration ships for evaluating the FM* innovations:

USS AINSWORTH (FF-1090)
USS MONTGOMERY (FF-1082)
USS MCCANDLESS (FF-1084)
USS MILLER (FF-1091)
USS MOINESTER (FF-1097)
USS CONNEL (FF-1056)
USS FAIRFAX COUNTY (LST-1193)
USS BOULDER (LST-1190)

PURPOSE

The purpose of this study is to demonstrate and evaluate methods for more efficient utilization of manpower while simultaneously improving condition, cleanliness, and appearance of ships' spaces, and improving FM skills and knowledge of ships' personnel engaged in FM. FM innovations will be tested and evaluated both in-port and at-sea, aboard operational units.

TEST OBJECTIVES

There are two categories of objectives for this test and evaluation: (1) those related to determining the operational effectiveness and feasibility of an integrated set of FM innovations (management, equipment, and training innovations); and (2) those related to developing a set of design specifications for a follow-on integrated FM system. The objectives presented below are based on the results of initial phases of the research.[1,2] Modifications to the system

[1]Superscripts refer to similarly numbered entries in the Technical References at the end of the text.
*Definitions of abbreviations used are given on page i.

previously evaluated have been made. The system of innovations for this test effort is described in the Description of the System section of this report (see page 6).

The following objectives address the operational effectiveness and feasibility of the FM innovations:

- Determine to what degree and at what cost implementation of FM equipment or material innovations alone (1) reduce FM man-hour expenditures; (2) improve material condition, cleanliness, and appearance of shipboard spaces; and (3) improve skill and knowledge of ships' personnel performing FM.

- Determine to what degree and at what cost FM management innovations alone (1) reduce FM man-hour expenditures; (2) improve material condition, cleanliness, and appearance of shipboard spaces; and (3) improve skill and knowledge of ships' personnel performing FM.

- Determine to what degree and at what cost FM training innovations alone (1) reduce FM man-hour expenditures; (2) improve material condition, cleanliness, and appearance of shipboard spaces; and (3) improve skill and knowledge of ships' personnel performing FM.

- Determine to what degree and at what cost combinations of FM innovations (1) reduce FM man-hour expenditures; (2) improve material condition, cleanliness, and appearance of shipboard spaces; and (3) improve skill and knowledge of ships' personnel performing FM.

- Determine effectiveness and reliability characteristics of labor-saving equipment selected for inclusion in this study.

- Assess the impact of FM equipment and material failures on (1) cleanliness, material condition, and appearance of ships' spaces and (2) FM man-hour expenditures.

The following objectives address the investigation of FM system performance and design parameters which may be used in the development of design specifications for follow-on designs in three areas: (1) equipment, (2) training and technical information, and (3) management and work distribution.

- Determine the effects of equipment casualties on FM work performance and procedures. Determine positive and negative features of FM equipment and materials.

- Determine positive and negative characteristics of training and technical information items.

- Determine positive and negative features of the workload distribution and the FM management and scheduling system.

- Determine advantages and disadvantages of utilizing the proposed manpower organization concept for shipboard FM.

- Investigate the favorable and unfavorable features of the following training equipment: (1) 35-mm audio-visual equipment and (2) 16-mm filmstrip audio-visual equipment.

SCOPE OF TEST

Each set of innovations (Management, Equipment, and Training) will be tested separately and in combination under both at-sea and in-port conditions. The extent to which these conditions sample all routine FM operations will depend on the schedule of test ships during testing.

The tests in this plan have been designed to collect data in four general categories:

- Performance and capabilities in an operational environment.

- Operational suitability in a Navy environment.

- Human factors aspects including human engineering design factors and personnel and training factors.

- Detailed engineering data required for possible follow-on efforts in this area.

LIMITATIONS OF SCOPE

Due to the innovative nature of this project, as well as cost and technological constraints, many elements of the total FM system are off-the-shelf equipment and materials which do not meet existing military specifications. Additionally, the use of existing shipboard FM equipment and materials will be observed in this evaluation. While this evaluation addresses the major portion of facilities maintenance performed by ships' forces, the following limitations are imposed:

- Facilities maintenance performed during overhaul or shipyard periods will not be addressed.

- Underwater hull cleaning or maintenance will not be addressed.

- Tasks currently in the Planned Maintenance System inventory, i.e., those for which maintenance requirement cards exist, will not be addressed.

- Vent and duct cleaning will not be addressed.

- Repair and replacement of nonpainted surfaces, e.g., replacement of vinyl asbestos tile or repair of terrazzo, will not be addressed.

GENERAL APPROACH

The general approach to be taken in this study is to conduct a controlled experiment aboard operational ships. Innovations will be installed aboard eight ships for approximately 1 year, during which time data relating to man-hour expenditures, condition cleanliness and appearance, equipment reliability and effectiveness, and effectiveness of management and training will be collected and analyzed.

RESEARCH DESIGN

Basically two separate studies will be conducted. The first is a comprehensive detailed investigation of the operational effectiveness and feasibility of three classes of innovation, separately and in combination. This study will utilize six FF-1052 class ships. Table 1 illustrates the different experimental treatment conditions assigned to each of the FF-1052 class ships.

The second study involves two LST-1179 class ships. One ship will have no innovations for the entire test period; the other will have all innovations. A more thorough technical description of the research design is presented in appendix A. Appendix B contains a discussion of the specific tests and data collection effort.

TABLE 1
EXPERIMENTAL TREATMENT CONDITION

Test Ship No.	Base Line Stage	1st Innovation Stage	2nd Innovation Stage
1	No innovations	No innovations	Mgmnt & Mnpwr innovations, Training innovations
2	No innovations	Mgmnt & Mnpwr innovations	Mgmnt & Mnpwr innovations, Training innovations
3	No innovations	Training innovations	Mgmnt & Mnpwr innovations, Training innovations
4	No innovations	Equipment innovations	Equipment innovations, Mgmnt & Mnpwr innovations, Training innovations
5	No innovations	Equipment innovations, Mgmnt & Mnpwr innovations	Equipment innovations, Mgmnt & Mnpwr innovations, Training innovations
6	No innovations	Equipment innovations, Training innovations	Equipment innovations, Mgmnt & Mnpwr innovations, Training innovations

DESCRIPTION OF THE SYSTEM

OVERVIEW

The Facilities Maintenance System is defined as that collection of personnel, equipment, materials, procedures, and information specifically designed or identified to perform all shipboard facilities maintenance actions. These

include cleaning, housekeeping, and preservation (surface preparation, corrosion control, and painting) tasks traditionally performed by ships' forces when not in a shipyard or overhaul period. The FMS includes innovations in equipment, materials, and the FM environment as well as new or improved procedures, training, and management techniques. But it is not completely new, and the conceptualization and design, particularly where FM equipment and materials are concerned, include a significant portion of existing shipboard FM capabilities. The list of FM equipment and material innovations (see below) shows the set of labor-saving devices and materials which will supplement existing equipment and materials aboard the ships in the test population.

It should be noted that specific FM requirements, and consequently specific software elements of the FM system, will vary because of the physical and basic mission differences between ship classes participating in this evaluation. However, the FM procedures, formats, and training concepts are considered common to all surface ship classes.

EQUIPMENT AND IMPROVED OPERATIONAL CAPABILITIES OFFERED

The following is a list of major equipment and materials to be evaluated:

- High-Pressure Washer System - A device which may provide easier, faster exterior deck washdowns, cleaning of the sides, surface preparation for painting, and bilge cleaning. The device reduces the existing requirement for freshwater generation and consumption and virtually eliminates difficult and lengthy scrubbing of sides and exterior surfaces.

- Wet Vacuum Cleaner - A device used for wet or dry pickup which provides easier and faster deck cleaning operations. It can eliminate standing water problems and reduce the number of rinsing operations involved in deck stripping and scrubbing operations.

- Portable ("Back Pack") Vacuum Cleaner with Pipe Cleaning Attachment - A device which provides more efficient, less tiring cleaning and dusting of overhead surfaces and pipes as well as horizontal and vertical surfaces. It is lightweight and relatively small, providing the operator with more mobility.

- Carpet Shampooer (Dry Foam) - A device which provides effective carpet cleaning and shampooing and prevents excessive drying time requirements normally associated with steam cleaning or conventional water extraction methods.

- Walk-Off Mats - Similar in concept to coco mats, these mats trap soil and lessen trackage of soil through clean ship spaces and carpeted areas. They are durable and require less maintenance than coco mats and offer better traction or nonskid features.

- Metalized Acrylic Deck Finish - This material, if applied to resilient deck surfaces, provides a durable, nonslippery, hard, lustrous deck surface which extends the intervals between required stripping. It is impervious to most chemical spills but can be easily removed with a special ammonia-based stripper.

- Airless Paint Spray Cup Gun - A device which can be used to perform touch-up and major area painting/coating. It is portable and considerably less complex to operate and maintain than conventional spray devices.

- Rotary Peening Devices - These devices remove paint and coating from metal substrates in less time and can bring a surface down to bare metal more effectively and with less noise than conventional deck scaling devices.

- Various chemicals and accessories.

MANAGEMENT SYSTEM DESCRIPTION

An information management and task scheduling system is currently under development and will be installed aboard selected test ships for evaluation. The components of the system follow:

- Facilities Maintenance Job Information Cards - Based on a highly detailed analysis of shipboard spaces, surfaces, cleaning requirements, and corrosion control requirements, all shipboard facilities maintenance tasks and requirements will be specified on a set of FMJIC's. The cards will define all FM work units (tasks) and will identify task periodicity, equipment/material requirements, procedures, safety precautions, and relevant training and technical references. Figures 1 and 2 show, in an illustrative format, the data contained on the FMJIC's.

- FM Schedules - A set of schedules, accounting for all FMJIC's, will be used for distributing daily, weekly, etc tasks to individuals.

- Training Record - Audio-visual training programs will be administered to all FM personnel. Upon completion of a training session, training records will be maintained by the central FM work center. Figure 3 presents the training record format.

JIC NO.	TASK	COMPARTMENT NO.	MAN HOURS	DATE
D-1	DUST/ SWEEP/ SWAB	01-108-4-L		1 SEP 77
NOUN NAME OF SPACE: Passageway			DIVISION ASSIGN: CS-1	ACTUAL JOB TIMES: FM _____ TO _____

EQUIPMENT REQUIRED

Straw broom, janitorial dust pan, clean cloths, swab, bucket with wringer, scrub-brush, trash receptacle liner, GP detergent sanitizer, foxtail, wet/dry vacuum.

SAFETY PRECAUTIONS

1. Mix detergent solutions in accordance with instructions on label.
2. Avoid cluttering area with cleaning gear.
3. Avoid eye contact with detergents.
4. Check electrical plug, electrical inspection tag and cord prior to using vacuum.

PROCEDURE

1. Pick up all loose trash and put in plastic liner.
2. Brush dust doors and hatches.
3. Vacuum overhead, wire runs and light fixtures.
4. Vacuum angle irons.
5. Sweep/dust ladders and back plates.
6. Sweep area thoroughly. Raise as little dust as possible. Sweep corners thoroughly.
7. Gather sweepings in dust pan and empty into plastic liner.
8. Swab deck with GP detergent solution.
9. Clean scuttlebutts with detergent sanitizer solution.
10. Replace plastic liners as required.
11. Clean and stow gear.

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Figure 1
FMJIC Format (Front)

REFERENCES

1. Training Module 1, Why We Clean.
2. Training Module 3, Cleaning Passageways, Ladders and Related Areas.
3. Navmed P-5010-2, Chapter 2, Sanitation of Living Spaces and Related Service Facilities, Section 2-1, 2-2, 2-3, 2-5 (a), 2-5 (c), 2-5 (e).

SPECIAL INFORMATION

Report chipped paint, rust, worn ladder treads and other damage to supervisor by using remarks section of this JIC in grease pencil.

REMARKS

PAGE 2 OF 2

D-1/CS-1

Figure 2
FMJIC Format (Reverse)

TRAINEE NAME	FM PERSONNEL TRAINING RECORD											
	Insert Dates of Training in Each Cell											
	Module											
	1	2	3	4	5	6	7	8	9	10	11	12

Figure 3
Format for Facilities Maintenance
Training Program Record

• All FM equipment and materials will be stored in specially designated FM cleaning-gear lockers. All items will be controlled by the division FM work center line supervisors, in the format as shown, figure 4.

Materials/Equipment Draw Log						
Item Description	Date	Time Out	Time In	Op Hours	Drawn By	Remarks

Figure 4
Format for Materials/Equipment
Draw Log

TRAINING PROGRAM DESCRIPTION

Twenty audio-visual training program and required display equipment will be installed aboard selected test ships. Two different display systems will be compared, viz: (1) 35-mm Kodak carousel projection system with optasonic playback device and (2) LaBelle 16-mm film soundstrip system.

The training module titles are as follows:

Module	Title
1	Why We Clean
2	Routine and Periodic Carpet Care
3	Cleaning Passageways, Ladders, Related Areas
4	Cleaning the Head and Showers

Module	Title
5	Cleaning the Galley and Scullery
6	Routine Care of Resilient and Terrazzo Decks
7	Cleaning the Mess Decks
8	Periodic Care of Resilient and Terrazzo Decks
9	Routine and Periodic Care of Bulkheads and Overheads
10	Cleaning Crew Living Spaces
11	Use of Sanitation and Facilities Maintenance Chemicals
12	Care of Facilities Maintenance Equipment
13	Safety in Shipboard Facilities Maintenance Operation
14-20	(Currently under development) (These modules will deal with surface preparation, corrosion, corrosion control, and painting.)

TECHNICAL MANUAL/HANDBOOKS

Technical manuals will be developed and distributed to selected test ships and will be evaluated in this study.

Technicians' Manual - This will be a comprehensive detailed manual describing all equipment/materials and procedures for each FMJIC task.

Supervisors' Manual - This manual will present detailed instructions to supervisors for scheduling, supervising, and inspecting all FM work.

DESCRIPTION OF OPERATIONAL CONCEPT AND MANNING

Two manpower concepts will be compared during this evaluation:

- Traditional FM manning and management as reflected in the Ship Manning Document, Ship's Organization and Regulation Manuals, and appropriate COMNAVSURFLANT instructions regarding manpower organization for the conduct of shipboard FM.

- Decentralized FM work centers with special centralized functions and services.

Each of these is described below.

Traditional FM Manning and Management

No changes to existing ship organizations and FM manning and management are to be effected. Data will be collected on this treatment condition for controlled comparisons.

Decentralized FM Work Centers with Centralized Functions and Services

Under this concept divisional FM work centers will be established. A central FM work center will also be established. A master set of FMJIC's and schedules will be maintained and serve as a reference within the central FM work center. Copies of the master set of FMJIC's and schedules will be subdivided in accordance with division space responsibilities, and the subsets will be used and maintained by the division FM work center.

A ship's instruction (to be promulgated) will be issued to appropriate test ships. The instruction will define the responsibilities, the FM work centers, and the recommended manpower organization and operational concept.

The recommended manning (for FF-1052 test ships) will be:

Central FM Work Center

Five non-watchstanders* from the 1st division (billets 04031 through 04035 (reference 3, page C-11)) providing 213 man-hours per week will be selected. These billets will comprise a permanent specialist team under the management and supervision of the 1st Lieutenant and under the first line supervision of the leading Boatswains Mate Chief.

All specialist team members will become proficient in the use, instruction, and safety aspects of all special equipment, materials and chemicals, and techniques which are developed under this program.

*A non-watchstander is defined as a person not required to stand a watch station under condition III or IV.

The functions of the specialist team will include:

- Performing FMJIC tasks within 1st division spaces and in other division spaces where use of special technique chemicals or equipment is indicated or where there are common use spaces.

- All spray painting.

- Training personnel from all FM work centers required to perform FMJIC tasks.

- Providing technical information/advice to other divisions.

- Inspection of FMJIC tasks at various stages of performance.

- Maintaining FM work and training records.

- Stowage and distribution of all special equipment and materials.

- Maintaining FM equipment records (hours of operation, repair/replacement records, etc).

- Collecting work record and inspection results from other divisions.

- Assisting other divisions in work scheduling, supervision, and management functions.

- Maintaining a complete technical data file, including manuals.

- Maintenance of special equipment.

Divisional Work Centers

Divisional FM work center manpower requirements are listed in table 2 along with the total weekly man-hour expenditures required. It should be noted that the total estimated manpower expenditure is approximately 65% of that currently listed in the Ship Manning Document for the FF-1052 class.

Each division shall be responsible for establishing the manpower organization required to accomplish the FM and shall maintain inspection and work records. Copies of these records shall be made available to test observers.

TABLE 2
DIVISIONAL MANPOWER REQUIREMENTS FOR IMPLEMENTATION OF DECENTRALIZED FM CONCEPT (FF-1052 CLASS)

Division	No. of Men	Weekly FM Man-Hour Contribution
X	2	18.20
01	3	54.80
OC	2	37.30
1st (deck division)	8	260.00
2nd	2	22.60
AS	3	60.50
M	3	83.00
B	2	41.60
R	3	94.00
S	7	250.20

FM work center supervisor shall issue FMJIC assignments to personnel required for FM duty via an assignment chit (figure 5). Supervision of FMJIC tasks will be performed by the FM work center supervisor or his representative.

Issue and stowage of equipment and chemicals will be performed by a representative of the FM work center supervisor. Distribution records will be maintained (for collection later) by this person. Special FM equipment and chemicals may also be issued through the central FM work center.

All personnel to which FMJIC tasks have been assigned will, as a minimum, receive training through the use of audio-visual or on-the-job training in the task prior to job performance. Arrangements for audio-visual training shall be made through the 1st division FM work center supervisor who will maintain all FM audio-visual training records.

Coordination among the central FM work center (also known as 1st division FM work center) and other division FM work centers shall be achieved by directive through the Executive Officer.

FACILITIES MAINTENANCE STUDY
DAILY TIME AND JOB TICKET

SHIP_____ DATE _____

FM SPVR _____
SIGNATURE

FM PERSONNEL ID _____
SIGNATURE

DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___

Figure 5
Assignment Chit

Spray painting may only be done under the supervision and management of the central FM work center supervisor. Cleaning and surface preparation functions requiring the use of specially furnished equipment/materials may only be done under the management and supervision of the central FM work center supervisor.

A similar concept (currently under development) will be used in testing the FMS aboard LST-1179 class ships. Separate instructions will be issued because of the size and organizational differences between the FF-1052 and LST-1179 class ships.

TEST PROGRAM

GENERAL

This test plan covers those tests that will be conducted by the Navy on the FM innovations previously mentioned. Where equipment, materials, and chemicals are concerned, a safety evaluation will precede shipboard installation. Few of these items are found in the Qualified Products List, and virtually none is service approved. The issue being examined is whether these product classes lead to achievement of program goals. When this question is answered, then it will be the responsibility of NAVSEC and NAVSEA to develop detailed specifications which meet service approval measurements prior to acquisition of specific items. It should be noted that a safety analysis has been performed to identify potential hazards to personnel.

DESCRIPTION OF TESTS

The Navy tests to be conducted fall into categories or segments. The segments overlap in time; hence, no sequencing in their accomplishment is implied. The segments are:

- Operational Effectiveness (o-tests).
- Operational Suitability (s-tests).
- Human Factors (h-tests).
- Detailed Design Considerations (d-tests).

Each test segment comprises a number of specific tests. The objectives, procedures, and data analyses planned for each of these tests are presented in the specific test plans in appendix B. The general purposes of the tests for each segment are presented below. Tests from two or more segments are expected to be conducted simultaneously in many cases.

The relationship among detailed tests and test objectives is shown in table 3.

TABLE 3
TEST OBJECTIVES AND ASSOCIATED TESTS

Page No.	Test Objective (Short Title)	Test No.	Test Title
3	Operational Effectiveness & Feasibility: Equipment/Materials	O-4	SOE, alone
3	Operational Effectiveness & Feasibility: Manpower/Management	O-2	MIM, alone
3	Operational Effectiveness & Feasibility: Training	O-3	TTI, alone
3	Operational Effectiveness & Feasibility: Combinations	O-1	SOE + MIM + TTI
		O-5	MIM + TTI
		O-6	SOE + MIM
		O-7	SOE + TTI
3	Labor-Saving Devices - Reliability & Effectiveness	S-1	Reliability
		D-1 thru D-6	Equipment Design Characteristics
		H-3	Human Engineering
3	Impact of Failures	O-4	SOE, alone
		O-1	SOE + MIM + TTI
		O-6	SOE + MIM
		O-7	SOE + TTI
		S-3	Availability
3	Equipment/Materials Design	S-1	Reliability
		D-1 thru D-6	Equipment Design Characteristics
		H-3	Human Engineering
		S-2	Maintainability
		S-3	Availability
		S-4	Supportability
		S-5	Compatibility
		H-1	Safety
3	Training & Technical Information Design	O-3	TTI, alone
		O-1	SOE + MIM + TTI
		O-5	MIM + TTI
		O-7	SOE + TTI
		D-8	Training Module Design
		D-9	Technical Manual Design
		H-2	Personnel & Training
4	Management System Design	O-2	MIM, alone
		O-1	SOE + MIM + TTI
		O-5	MIM + TTI
		O-6	SOE + MIM
		S-5	Compatibility
		S-4	Supportability
4	Manpower	O-1	SOE + MIM + TTI
		H-2	Personnel & Training
		O-5	MIM + TTI
		O-6	SOE + MIM
		O-2	MIM, alone
		S-4	Supportability
4	Training Equipment	H-2	Personnel & Training
		S-5	Compatibility
		S-4	Supportability

Segment I: Operational Effectiveness

Tests in this segment will assess the operational effectiveness of all combinations of FM innovations (equipment, materials, training, and manpower and management) under normal operational conditions (at-sea and in-port without overhaul or shipyard periods).

Segment II: Operational Suitability

This segment of tests will evaluate the suitability of the various FM innovations for operational use by the Navy. This includes equipment reliability, availability of equipment and materials, practicality of manpower and management concepts tested, equipment maintainability, and supportability in the Navy operational environment. Since this system of innovations is developmental, test results in this area will serve a dual purpose: to provide preliminary estimates of suitability and diagnostic information for future design improvements.

Segment III: Human Factors

These tests will investigate the human engineering and personnel and training aspects of the FM system. Human engineering checklists will be used to evaluate the operability and maintainability design features of FM equipment. Data will be collected to determine an efficient and effective mix of personnel numbers and skills for FM accomplishment.

Segment IV: Detailed Design Considerations

The data to be collected for these tests will be used to develop specifications and procedures for future FM system design particularly in the software areas, vis: training programs, manuals, management systems, and technical data.

TESTS AND OBJECTIVES

Segment I Tests - Operational Effectiveness*

- O-1: Overall System Effectiveness (SOE + MIM + TTI) - Assess the operational effectiveness of the total system of FM innovations.

*Effectiveness is defined as the ability to reduce FM man-hour expenditures while maintaining or improving cleanliness, material condition, and appearance of ship spaces.

- 0-2: Manpower and Management Systems (MIM) - Assess the effectiveness of the manpower organization concepts and the information management and scheduling system.

- 0-3: Training and Technical Information (TTI) - Assess the effectiveness of the training modules and technical manuals.

- 0-4: Equipment and Materials (SOE) - Assess the effectiveness of each of the equipment and material items.

- 0-5: Manpower and Management System and Training (MIM + TTI) - Assess the effectiveness of the manpower management system combined with training, but without the equipment or materials innovations.

- 0-6: Equipment, Materials, and Manpower and Management System (SOE + MIM) - Assess the effectiveness of the equipment and material items combined with the manpower and management system, but without training and technical information.

- 0-7: Equipment, Materials, and Training and Technical Information (SOE + TTI) - Assess the effectiveness of equipment and materials combined with training and technical information, but without the manpower and management system.

Segment II Tests - Operational Suitability

- Test S-1: Equipment/Material Reliability - Assess the reliability of FM equipment and materials in an operational environment.

- Test S-2: Equipment/Materials Availability - Assess the availability of the FM equipment and materials in an operational environment.

- Test S-3: Equipment/Material Maintainability - Assess the maintainability of equipment or materials in an operational environment.

- Test S-4: Supportability - Assess the supportability of the overall FM system.

- Test S-5: Compatibility - Assess the compatibility of equipment and materials and manpower concepts with Navy facilities and surfaces found on ships in an operational environment.

Segment III Tests - Human Factors

- Test H-1: Safety - Determine if FM equipment and materials can be safely handled.

- Test H-2: Personnel and Training - Determine skill level and training required to operate and maintain FM equipment.

- Test H-3: Human Engineering - Assess the adequacy of equipment design for operability and maintainability.

Segment IV Tests - Detailed Design Considerations

- Test D-1: Pressure Washer System Performance - Assess the ability of the pressure washers to clean exterior deck surfaces, sides, and bilge areas.

- Test D-2: Wet Vacuum Performance - Assess the ability of the wet vacuums to be used in deck stripping and other wet pickup operations.

- Test D-3: Portable Vacuum Performance - Assess the ability of the portable vacuum to be used in cleaning overheads and other surfaces.

- Test D-4: Carpet Shampooer Performance - Assess the ability of the carpet shampooer to be used for carpet maintenance operation.

- Test D-5: Rotary Peening Device Performance - Assess the ability of the rotary peening devices to be used for surface preparation prior to painting.

- Test D-6: Rotary Floor Machine Operation - Assess the ability of the two-speed motor floor machine to be used for deck stripping, scrubbing, and spray buffing operation.

- Test D-7: FMJIC's and FM Schedules - Assess the design of the FMJIC formats and methods for distributing, managing, and supervising FM workload.

- Test D-8: Training Program Modules - Assess the technical content of the audio-visual training modules both in 35- and 16-mm formats.

- Test D-9: Technical Manuals and Handbooks - Assess the utility of the technical manuals and handbooks.

TEST ELEMENTS

PARTICIPATING ACTIVITIES

DTNSRDC is the principal developing agency for the FM system and has overall responsibility to develop, install, and test the FM system.

COMOPTEVFOR has been requested to provide an independent assessment of the FM system operational suitability.

COMNAVSURFLANT has been requested to provide such assistance as may be required to COMOPTEVFOR for the execution of the FM system evaluation project.

NPRDC was asked to provide technical assistance in all aspects of this test and evaluation effort.

The Stanwick Company is the prime contractor for the FM software.

Points of contact for the FM test project are:

OPNAV (OP 37) - CDR M. Kiefer - AV 222-6383

NAVMAT (MAT 03) - Program Administrator - Mr. A. Rubinstein - AV 222-2144

NAVSEA (SEA 03) - Program Monitor - Mr. J. Sejd - AV 222-8540

DTNSRDC (Code 2784) - Program Manager/Project Officer - LCDR D. Vetter - AV 281-2764

DTNSRDC (Code 2784) - Deputy Program Manager - Vacant - AV 281-2764

NPRDC (Code 311) - Principal Investigator and Test Director - Mr. M. Schwartz - AV 281-3625

COMNAVSURFLANT (N63) - Project Officer - LCDR T. Luckman - AV 690-5387

COMOPTEVFOR (Code 732) - Project Officer - LCDR A. Van Allman - AV 690-5075

Commanding Officers of ships listed below.

TEST SHIPS

The following test ships have been designated for participation in this program:

USS AINSWORTH (FF-1090)

USS MONTGOMERY (FF-1082)

USS MCCANDLESS (FF-1084)

USS MILLER (FF-1091)

USS MOINESTER (FF-1097)

USS CONNEL (FF-1056)

USS FAIRFAX COUNTY (LST-1193)

USS BOULDER (LST-1190)

Various portions of the system will be installed aboard the test ships for approximately 1 year. Equipment will be removed prior to shipyard overhaul. Ships' personnel will be selected and trained to operate and maintain the equipment during the testing period.

INSTRUMENTATION

No instrumentation beyond that provided by the ships or project office will be required.

SUPPORT REQUIREMENTS

The following are the basic support requirements and responsibilities for the test project:

- An operational test director has been provided by NPRDC.

- Test ships will provide a test project liaison officer and office space for data handling.

- All spares and test materials will be provided by the project office.

- Personnel resources required for test observation and data recording will be provided by the project office and the test ships. Approximately a 180-man-day data collection support will be provided by DTNSRDC during the 1-year test period. Appendix B provides detailed instructions for data takers.

- Data analyses support will be provided by the project office. This includes statistical, Navy, technical, and data processing support personnel. Approximately 200 man-days of effort is anticipated and will be provided by DTNSRDC and NPRDC.

- Qualified officers and enlisted personnel will be provided by the ship for operation and maintenance of the FM system.

- Manufacturers' technical representatives will provide maintenance and repair assistance as required.

TEST SCHEDULE

The subject test programs will commence on or about 15 January 1978 (with base line data collection). Installation will take place on or about 15 July 1978. The program test will terminate approximately 15 July 1979.

Appendix B contains detailed descriptions of each of the tests to be conducted during the evaluation period.

Table 3 presents a matrix of test objectives and related detailed tests.

TEST DATA

The specific test parameters which will be recorded during each test and sample data sheets are included in appendix B. The test director has the authority to modify data collection sheets and procedures as he deems necessary. He will also review all data records to determine the necessity for repeating tests.

REPORTS

The following schedule of reporting will be adhered to during the test program:

- Monthly SITREPS will be issued by the DTNSRDC test director to COMOPTEVFOR, COMNAVSURFLANT, NAVSEA, and DTNSRDC.

- A deficiency status report (if required) will be issued by DTNSRDC.

- A final report will be issued by DTNSRDC or NPRDC after test completion.

TECHNICAL REFERENCES

1 - Schwartz, M. A., "Shipboard Facilities Maintenance and Manpower Utilization: Problem and Approach," NPRDC TR 76-22, San Diego, Cal. (Nov 1975)

2 - Schwartz, M. A., "Facilities Maintenance Demonstration Study," NPRDC TR 76-29, San Diego, Cal. (Jan 1976)

3 - OPNAV 10-P53 Ship Manning Document, DE-1052 Class Escort

APPENDIX A

RESEARCH DESIGN

1.0 Introduction

This appendix presents the research design and methodology for this test program. The overall test approach is an operational experiment involving six FF-1052 class ships and two LST-1179 class ships.

Two separate studies will be performed. The first, utilizing the FF-1052 class ships, is a comprehensive, highly detailed investigation of the operational effectiveness and feasibility of each class of FM innovation and various combinations of innovations. The second, involving two LST-1179 class ships, is for the purpose of demonstrating the overall feasibility of implementing the FM innovations aboard a large surface ship with a different mission and a different kind of FM requirement. Despite the difference in purposes of the two studies, the general research hypotheses, design, and methodology are quite similar and data collection methods are the same.

2.0 Independent Variables

2.1 General - The experimental design of this study program is a plan for applying different experimental conditions, or independent variables, to test ships to determine how such conditions affect the criteria, or dependent variables. Each independent variable can assume different values or levels. In these experiments each independent variable can assume two levels, viz, with and without.* In the design that follows, each test ship will be exposed to only one level of experimental condition within a specified data collection time interval. Each data collection time interval comprises a quarter (3-month period), and there is a total of four consecutive quarters. Additionally, prior to implementing the experimental conditions for the four consecutive quarters, base line data collection will be conducted aboard the test ships. This means that, in addition to the comparisons between test ships exposed to the various experimental treatments, each ship will act as its own control within ship comparisons for the base line data representing the "without" level of the independent variable.

*"With" represents the presence of the FM innovation; "without" represents the absence of the FM innovation.

2.2 Three Independent Variables - The independent variables in this program are the following:

2.2.1 Suit of Equipment/Material - The SOE constitutes those items of FM equipment, materials, and chemicals which were previously discussed and are not part of the normal ship's allowance list. Quantities per ship of each item will be based on a detailed requirement analysis and will be the same for each ship of a given class.

2.2.2 Manpower and Information Management - The MIM comprises the information management system (FMJIC's and management schedules) and the manpower organization concepts presented in the text of this report (see page 8).

2.2.3 Training and Technical Information - TTI consists of 20 audio-visual training programs, technical manuals, and related technical information.

3.0 Dependent Variables

3.1 General - The purpose of these studies is to ascertain how the different experimental treatment conditions, or independent variables, affect criterion measures or dependent variables. Looking back at the goals of this program, the criteria include reduced man-hour requirements, improved levels of cleanliness, condition, and appearance, and increased skill and knowledge of FM personnel.

3.2 Measures - There are three dependent measures addressed in the studies:

3.2.1 FM Man-Hour Expenditures - Throughout the conduct of this study data concerning FM man-hour expenditures will be collected. The FMJIC or its equivalent recording form (for those test ships not having FMJIC's) will be used to compile the number of man-hours spent on each FM task. The data will be aggregated on a weekly basis. The statistic of concern here is the average weekly man-hour expenditure.

3.2.2 Level of Condition, Cleanliness, and Appearance - It must be recognized that, where cleanliness, condition, and appearance are concerned, no practical objective standard exists. How clean is clean depends to a large degree on the subjective impressions of the observer. Different Commanding Officers have different perceptions of adequate levels of cleanliness. There are numerous objective criteria which can be used in a laboratory. These include gloss meters, thickness sensors, and others. However, it would be neither practical nor meaningful to attempt to use such devices. Consequently, a subjective evaluation scale will be used by trained observers to develop indices of cleanliness,

appearance, and condition. The scale and its method of use is discussed in appendix B.

3.2.3 Skill/Knowledge of FM Personnel - The measure of skill and knowledge is a score on a paper-and-pencil test developed specifically for use in this program (see appendix B).

4.0 Research Hypotheses

There are three major hypotheses to be tested to answer the questions of operational effectiveness of the innovation:

4.1 Hypothesis 1 - There will be fewer man-hours spent on facilities maintenance as a result of the innovations (separately, and in combination).

4.2 Hypothesis 2 - Subjective ratings of cleanliness, appearance, and condition will indicate an improvement or "no change" due to the FM innovations.

4.3 Hypothesis 3 - Skill and knowledge of FM personnel will improve as a result of implementing the FM innovations.

5.0 The FF-1052 Experiment - Three-Factor Experimental Model

5.1 The Linear Model - In this experiment there will be three factors (independent variables) and three criteria (dependent variables). The relationships between the factors and criteria have been hypothesized in the previous section.

Let A, B, and C be the independent variables of SOE, MIM, and TTI, respectively. There are two possible levels (see footnote, page A-1) for each, i.e., levels of A = levels of B = levels of C = 2.

Let W_{ijkl} be the observations of man-hours spent in doing FM; X_{ijkl} be the observations of subjective ratings of cleanliness, condition, and appearance of shipboard spaces, and Y_{ijkl} be the skill and knowledge scores of personnel performing FM.

A, B, and C are arranged in factorial treatment combinations. That is, each complete trial of the experiment contains all possible A, B, C treatment combinations.

The observations W_{ijkl}, X_{ijkl}, and Y_{ijkl} may be described by the linear model:

$$W_{ijkl} = \mu_w + \alpha_{w_i} + \beta_{w_j} + \gamma_{w_k} + (\alpha_w\beta_w)_{ij} + (\alpha_w\gamma_w)_{ik}$$

$$+ (\beta_w\gamma_w)_{jk} + (\alpha_w\beta_w\gamma_w)_{ijk} + \epsilon_{w_{ijkl}} \qquad \text{(A-1)}$$

$$X_{ijkl} = \mu_x + \alpha_{x_i} + \beta_{x_j} + \gamma_{x_k} + (\alpha_x\beta_x)_{ij} + (\alpha_x\gamma_x)_{ik}$$

$$+ (\beta_x\gamma_x)_{jk} + (\alpha_x\beta_x\gamma_x)_{ijk} + \epsilon_{x_{ijkl}} \qquad \text{(A-2)}$$

$$Y_{ijkl} = \mu_y + \alpha_{y_i} + \beta_{y_j} + \gamma_{y_k} + (\alpha_y\beta_y)_{ij} + (\alpha_y\gamma_y)_{ik}$$

$$+ (\beta_y\gamma_y)_{jk} + (\alpha_y\beta_y\gamma_y)_{ijk} + \epsilon_{y_{ijkl}} \qquad \text{(A-3)}$$

where $i = 1, 2$; $j = 1, 2$; $k = 1, 2$; $l = 1, 2 \ldots N$;

μ_w, μ_x, μ_y

are the overall mean effects of man-hours spent on FM, subjective ratings of cleanliness, condition, and appearance, and skill and knowledge test scores of FM personnel, respectively;

α_{w_i}, α_{x_i}, and α_{y_i}

are the true effects of the ith level of treatment A;

β_{w_j}, β_{x_j}, and β_{y_j}

are the true effects of the jth level of treatment B;

γ_{w_k}, γ_{x_k}, and γ_{y_k}

are the true effects of the kth level of treatment C;

$(\alpha_w\beta_w)_{ij}$, $(\alpha_x\beta_x)_{ij}$, and $(\alpha_y\beta_y)_{ij}$

are the effects of the interactions between α_i and β_j;

$(\alpha_w\gamma_w)_{ik}$, $(\alpha_x\gamma_x)_{ik}$, and $(\alpha_y\gamma_y)_{ik}$

are the effects of the interactions between α_i and γ_k;

$(\beta_w\gamma_w)_{jk}$, $(\beta_x\gamma_x)_{jk}$, and $(\beta_y\gamma_y)_{jk}$

are the effects of interactions between β_j and γ_k;

$(\alpha_w\beta_w\gamma_w)_{ijk}$

is the effect of the three factors (α_i, β_j, γ_k) interaction; and

$(\epsilon_w)_{ijkl}$, $(\epsilon_x)_{ijkl}$, and $(\epsilon_y)_{ijkl}$

are the random errors of W, X, and Y, respectively. The data for such a three-way (A, B, C) classification analysis of variance may appear as in table 1-A.

An interaction means that the treatment effect, say $\alpha_{\overline{w}_i}$, does not remain the same over different levels of treatment B. That is to say, the effect of one level of treatment A on the response depends upon the level of treatment B.

Sets of treatments A, B, and C can be assumed to be fixed effects. We are interested in estimating the parameters in the linear models (e.g., 1, 2, 3, 4) and testing various hypotheses about them.

The statistical analytical procedure consists of partitioning the total variation in the observations into components due to main effects, two-factor interactions, three-factor interactions, and random errors. This partitioning is ($\overline{w}$ only).

TABLE 1-A
DATA FOR A THREE-FACTOR CLASSIFICATION
ANALYSIS OF VARIANCE ($\bar{w}$ ONLY)
C (TRAINING FACTOR)

		C = 1 (NO TRAINING)			C = 2 (WITH TRAINING)	
		B (IMS VARIABLE)			B (IMS VARIABLE)	
		b = 1 (NO IMS)	b = 2 (WITH IMS)		b = 1	b = 2
A SOE VARIABLE	a = 1 NO SOE	x_{1111}	x_{1211}	A SOE VARIABLE a = 1	x_{1121}	x_{1221}
		x_{1112}	x_{1212}		x_{1122}	x_{1222}
		x_{1113}	x_{1213}		x_{1123}	x_{1223}
		.	.		.	.
		.	.		.	.
		.	.		.	.
		x_{111n}	x_{121n}		x_{112n}	x_{122n}
	a = 2 WITH SOE	x_{2111}	x_{2211}	a = 2	x_{2121}	x_{2221}
		x_{2112}	x_{2212}		x_{2122}	x_{2222}
		x_{2113}	x_{2213}		x_{2123}	x_{2223}
		.	.		.	.
		.	.		.	.
		.	.		.	.
		x_{211n}	x_{221n}		x_{212n}	x_{222n}
Total Number of Data = 2(2)2(n) = 8n						

$$(SS_w)_T = (SS_w)_A + (SS_w)_B + (SS_w)_C + (SS_w)_{AB} + (SS_w)_{AC}$$

$$+ (SS_w)_{BC} + (SS_w)_{ABC} + (SS_w)_E \qquad (A-4)$$

In order to develop computational expressions for the sums of squares, let

$T_{w_{i...}}$ be the total under the ith level of A;

$T_{w_{.j..}}$ be the total under the jth level of B;

$T_{w_{..k.}}$ be the total under the kth level of C.

The three-way totals are $(T_w)_{ijk}$, and the grand total is $(T_w)_{....}$. Expressed mathematically,

$$(T_w)_{i...} = \sum_{j=1}^{2} \sum_{k=1}^{2} \sum_{l=1}^{n} W_{ijkl}, \quad i = 1, 2$$

$$(T_w)_{.j..} = \sum_{i=1}^{2} \sum_{k=1}^{2} \sum_{l=1}^{n} W_{ijkl}, \quad j = 1, 2$$

$$(T_w)_{..k.} = \sum_{i=1}^{2} \sum_{j=1}^{2} \sum_{l=1}^{n} W_{ijkl}, \quad k = 1, 2$$

$$(T_w)_{ij..} = \sum_{k=1}^{2} \sum_{l=1}^{n} W_{ijkl}, \quad i = 1, 2; \quad j = 1, 2$$

$$(T_w)_{i.k.} = \sum_{j=1}^{2} \sum_{l=1}^{n} W_{ijkl}, \quad i = 1, 2; \quad k = 1, 2$$

$$(T_w)_{.jk.} = \sum_{i=1}^{2} \sum_{l=1}^{n} W_{ijkl}, \quad j = 1, 2; \quad k = 1, 2$$

$$(T_w)_{ijk.} = \sum_{l=1}^{n} W_{ijkl}, \quad i = 1, 2; \quad j = 1, 2; \quad k = 1, 2$$

$$(T_w)_{....} = \sum_{i=1}^{2} \sum_{j=1}^{2} \sum_{k=1}^{2} \sum_{l=1}^{n} W_{ijkl}$$

The computational formulas for the sums of squares for the main effects are:

$$(SS_w)_A = \frac{\sum_{i=1}^{2} (T_w)^2_{i...}}{n(4)} - \frac{(T_w)^2_{....}}{8n} \qquad \text{(A-5)}$$

$$(SS_w)_B = \frac{\sum_{j=1}^{2} (T_w)^2_{.j..}}{4n} - \frac{(T_w)^2_{....}}{N} \qquad \text{(A-6)}$$

$$(SS_w)_C = \frac{\sum_{k=1}^{2} (T_w)^2_{..k.}}{4n} - \frac{(T_w)^2_{....}}{N} \qquad \text{(A-7)}$$

where $N = abcn = 2(2)2\ n = 8n$.

The computational formulas for the sums of squares between two treatments are:

$$(SS_w)_{AB} = \frac{1}{cn} \sum_{i=1}^{2} \sum_{j=1}^{2} (T_w)^2_{ij..} - \frac{(T_w)^2_{....}}{N}$$

$$- (SS_w)_A - (SS_w)_B \qquad \text{(A-8)}$$

$$(SS_w)_{AC} = \frac{1}{bn} \sum_{i=1}^{2} \sum_{k=1}^{2} (T_w)^2_{i.k.} - \frac{(T_w)^2_{....}}{N}$$

$$- (SS_w)_A - (SS_w)_C \qquad \text{(A-9)}$$

$$(SS_w)_{BC} = \frac{1}{an} \sum_{j=1}^{2} \sum_{k=1}^{2} (T_w)^2_{.jk.} - \frac{(T_w)^2_{....}}{N}$$

$$- (SS_w)_B - (SS_w)_C \qquad \text{(A-10)}$$

To compute the sum of squares for the three-factor interaction, we have

$$(SS_w)_{ABC} = \frac{1}{n} \sum_{i=1}^{2} \sum_{j=1}^{2} \sum_{k=1}^{2} (T_w)^2_{ijk.} - \frac{(T_w)^2_{....}}{N}$$

$$- (SS_w)_A - (SS_w)_B - (SS_w)_C - (SS_w)_{AB}$$

$$- (SS_w)_{AC} - (SS_w)_{BC} \qquad \text{(A-11)}$$

The total sum of squares is

$$(SS_w)_T = \sum_{i=1}^{2} \sum_{j=1}^{2} \sum_{k=1}^{2} \sum_{l=1}^{n} \overline{W}^2_{ijkl} - \frac{(T_w)^2_{....}}{N} \qquad \text{(A-12)}$$

The sum of the squares error is

$$(SS_w)_E = (SS_w)_T - (SS_w)_A - (SS_w)_B - (SS_w)_C - (SS_w)_{AB}$$

$$- (SS_w)_{AC} - (SS_w)_{BC} - (SS_w)_{ABC} \qquad \text{(A-13)}$$

Assuming that A, B, and C are fixed effects, we may formulate hypotheses about the main effects and interactions in the model, equation (A-1).

Similarly, $\overline{X}$, $\overline{Y}$, and Z models, namely, equations (A-2), (A-3), and (A-4), can be tested.

In this problem, we are interested in testing hypotheses about the treatment effects.

The analysis of variance table is given in table 2-A. From the expected mean squares, which are shown in the table, we may construct appropriate test statistics, F statistics. Usually, the three-way interaction is tested first, the two-way interactions next, and the main effects last. The existence of significant interactions may tend to mask the existence of main effects.

5.2 Test Ships - Arrangement of FM Innovations - There are six FF-1052 class ships in the test population for the study. The FM innovations (SOE, MIM, TTI) of the various ships against time will be arranged as shown in table 3-A.

5.3 Sample Size Estimation - In this experiment all factor levels are to have equal sample sizes. This reflects the opinion that the independent variables are of equal importance.

Referring to Neter and Wasserman* (pages 492-498 and 601-602), charts are available for determining sample size for analysis of variance. These charts (table A-10, pages 827-828) require the following specifications:

1. The level α at which the risk of making a type I error is to be controlled.

2. The value of ϕ' at which the risk of making a type II error is to be controlled.

3. The level β at which the risk of making a type II error is to be controlled.

*Neter, J., and W. Wasserman, Applied Linear Statistical Models, Irwin, Inc., Homewood, Ill. (1974).

TABLE 2-A
ANALYSIS OF VARIANCE TABLE FOR THE THREE-WAY CLASSIFICATION, FIXED EFFECTS MODEL
($\overline{w}$ ONLY)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Mean Squares	F° Test
A	$(SS_w)_A$	1	$M(S_w)_A$	$\sigma^2 + 4n \sum_{i=1}^{2} \alpha w_i^2$	$F° = \frac{M(S_w)_A}{M(S_w)_E}$
B	$(SS_w)_B$	1	$M(S_w)_B$	$\sigma^2 + 4n \sum_{j=1}^{2} \beta w_j^2$	$F° = \frac{M(S_w)_B}{M(S_w)_E}$
C	$(SS_w)_C$	1	$M(S_w)_C$	$\sigma^2 + 4n \sum_{k=1}^{2} \gamma w_k^2$	$F° = \frac{M(S_w)_C}{M(S_w)_E}$
AB	$(SS_w)_{AB}$	1	$M(S_w)_{AB}$	$\sigma^2 + 2n \sum_{i=1}^{2} \sum_{j=1}^{2} (\alpha_w \beta_w)_{ij}^2$	$F° = \frac{M(S_w)_{AB}}{M(S_w)_E}$
AC	$(SS_w)_{AC}$	1	$M(S_w)_{AC}$	$\sigma^2 + 2n \sum_{i=1}^{2} \sum_{k=1}^{2} (\alpha_w \gamma_w)_{ik}$	$F° = \frac{M(S_w)_{AC}}{M(S_w)_E}$
BC	$(SS_w)_{BC}$	1	$M(S_w)_{BC}$	$\sigma^2 + 2n \sum_{j=1}^{2} \sum_{k=1}^{2} (\beta_w \gamma_w)_{jk}$	$F° = \frac{M(S_w)_{BC}}{M(S_w)_E}$
ABC	$(SS_w)_{ABC}$	1	$M(S_w)_{ABC}$	$\sigma^2 + n \sum_{i=1}^{2} \sum_{j=1}^{2} \sum_{k=1}^{2} (\alpha_w \gamma_w \beta_w)_{ijk}$	$F° = \frac{M(S_w)_{ABC}}{M(S_w)_E}$
Error	$(SS_w)_E$	$8(n-1)$	$M(S_w)_E$	σ^2	
Total	$(SS_w)_T$	$8(n-1)$			

where

$$M(S_w)_A = \frac{(SS_w)_A}{a-1} = (SS_w)_A \qquad M(S_w)_{AC} = \frac{(SS_w)_{AC}}{(a-1)(c-1)} = (SS_w)_{AC}$$

$$M(S_w)_B = \frac{(SS_w)_B}{b-1} = (SS_w)_B \qquad M(S_w)_{BC} = \frac{(SS_w)_{BC}}{(b-1)(c-1)} = (SS_w)_{BC}$$

$$M(S_w)_C = \frac{(SS_w)_C}{c-1} = (SS_w)_C \qquad M(S_w)_{ABC} = \frac{(SS_w)_{ABC}}{(a-1)(b-1)(c-1)} = (SS_w)_{ABC}$$

$$M(S_w)_{AB} = \frac{(SS_w)_{AB}}{(a-1)(b-1)} = (SS_w)_{AB} \qquad M(S_w)_E = \frac{(SS_w)_E}{abc(n-1)} = (SS_w)_{E/8(n-1)}$$

TABLE 3-A
ARRANGEMENT OF FM INNOVATIONS BY
TEST SHIP (FF-1052 CLASS)

Test Ship Number	Time			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1	1 1 1	1 1 1	1 1 1	1 2 2
2	1 2 1	1 2 1	1 2 1	1 2 2
3	1 1 2	1 1 2	1 1 2	1 2 2
4	2 1 1	2 1 1	2 1 1	2 2 2
5	2 2 1	2 2 1	2 2 1	2 2 2
6	2 1 2	2 1 2	2 1 2	2 2 2

where the three-digit number in a cell stands for abc. For example, at second quarter, ship 4 is equipped with SOE, NO IMS, and NO TRAINING, i.e., a = 1, b = 1, and c = 2.

When using the sample size chart,* two α levels and five β levels are available:

$$\alpha = 0.01, 0.05$$

$$\beta = 0.5, 0.3, 0.2, 0.1, 0.05.$$

Also ϕ' is given by equation (5.2),* as

$$\phi' = \frac{1}{\delta}\sqrt{\frac{\Sigma \tau_j^2}{r}}$$

With the power method approach, one can first specify values for the set of parameters (α, β, ϕ') for which it is important to detect factor A effects and obtain the needed sample size from the sample chart, with r = 2. The resulting sample size is bcn = 4n, from which n can be readily obtained. The minimum size is limited by the condition $a(bcn-1) \geq 20$ or $2(4n-1) \geq 20$, $8n \geq 22$, $n \geq 3$.

(i) For the man-hour shipboard FM case, let us take:

α = 0.05 (type I error)

β = 0.1 (type II error)

r = 2 (two levels)

σ = 10 min (est)

μ_1 = 105 min (est)

μ_2 = 63 min

Then

$$1/2 \sum_{j=1}^{2} \tau_j^2 = 441 \text{ min}$$

$$\phi' = 2.1$$

From table A-10, page 827,* we find:

$$n = 5 \quad (\alpha = 0.05,\ P = 1-\beta = 0.9,\ \phi' = 2.1)$$

Therefore, bcn = 4(5) = 20 is needed.

The resulting sample size for man-hour shipboard FM case is 20.

(ii) For subjective ratings of cleanliness conditions and appearance, again let us take α = 0.05, β = 0.1, r = 2.

μ_1 = 3.5

σ = 0.8

μ_2 = 3.2 (est)

Using equation (15),* we have:

$$\mu = 1/2\ (3.5 + 3.2) = 3.35$$

$$1/2\ \Sigma\ \tau_j^2 = 1/2\ [(3.35 - 3.5)^2 + (3.35 - 3.2)^2] = (0.15)^2$$

$$\phi' = \frac{0.15}{0.8} = 0.188$$

We find n = 100 from table A-10, page 827.* Therefore, the sample size needed for our three-factor experimental case is 4 x 100 = 400.

(iii) For the case of skill and knowledge levels, we take:

$\alpha = 0.05$, $\beta = 0.1$, $r = 2$, and

$\mu_1 = 60$ points

$\sigma = 8$ points

$\mu_2 = 60 + 10.6 = 70.6$ points

Equation (15)* gives:

$$\mu = 1/2\ (\mu_1 + \mu_2) = 1/2\ (60 + 70.6) = 65.3$$

$$1/2\ \Sigma\ \tau_j = 1/2\ [(60 - 65.3)^2 + (70.6 - 65.3)^2] = (5.3)^2$$

$$\phi' = \frac{5.3}{8} = 0.663$$

From table A-10, page 827,* it is found that n = 13 or the needed sample size is 4 x 13 = 52.

6.0 The LST-1179 Experiment

In this experiment all innovations will be installed aboard one of the two test ships after base line data collection aboard both. The basic experimental design model is

called nonequivalent control group design. The design is illustrated symbolically as follows:

$$t_1 - \frac{O}{O} - \underline{X} - \frac{O}{O}\ t_2$$

where O = a set of observations, X = the establishment of treatment condition, t_1 = time prior to X, and t_2 = time following X. That is,

(1) Data will be collected from two ships.

(2) One of the ships will be designed as the test ship on a random basis.

(3) FM innovations will be installed aboard the test ship.

(4) Data will be collected from both ships for the duration of testing (1 year).

APPENDIX B

DETAILED TESTS AND DATA COLLECTION INSTRUCTIONS

TEST SEGMENT I

TESTS 0-1 THROUGH 0-7 OPERATIONAL EFFECTIVENESS

I. Purpose. Assess the operational effectiveness of FM innovations (SOE, MIM, TTI) singly and in combination.

1. Determine degree of savings in FM man-hours per week accrued as a result of implementing FM innovations in all combinations of innovation classes. The combinations are as follows:

a. SOE + MIM + TTI (test 0-1).

b. MIM alone (test 0-2).

c. TTI alone (test 0-3).

d. SOE alone (test 0-4).

e. MIM + TTI (test 0-5).

f. SOE + MIM (test 0-6).

g. SOE + TTI (test 0-7).

These tests will allow the determination of the most cost effective combination of innovation packages which lead to man-hour savings.

2. Determine degree of improvement in cleanliness, condition, and appearance resulting from implementing the FM innovations in all combinations of innovation classes. The combinations are as mentioned above (I.1.).

II. Procedures.

1. FM Man-Hours Expenditure.

These tests will be conducted in port and at sea, before and after FM innovations are installed aboard ships in accordance with table 3-A, appendix A. FM man-hours expenditure data will be collected during a 3-month base line data collection period prior to installation and on all ships throughout the testing period. Data sheet 0-1A (figure 1-B) will be used to collect data on all ships during base line data collection and test data collection on all ships. The

divisional work center supervisor will use this data sheet to assign jobs to each individual (one sheet per individual per assignment period). The FM personnel will complete the work listed on the sheet, fill in the number of hours and minutes spent, and return the sheet to the supervisor. It is a two-part form. The supervisor will retain one part and store one for later delivery to the study staff. This data sheet will be collected by test observers during periodic visits with shipboard supervisors responsible for assigning FM work to personnel. Since the FM work must be assigned on an individual basis by the supervisor, there will be a minimum of extra paperwork required to record these data.

During the base line data collection period, frequency of data collection activities will be determined by the test director. As a minimum goal, 12 full weeks of FM man-hour expenditure data on each of the eight ships (six FF-1052 and two LST-1179 class ships) is desired.

2. Cleanliness, Condition, and Appearance.*

These tests will be conducted by:

a. Teams of test observers.

b. Supervisors responsible for assigning FM work.

c. Officers.

Tests will be conducted in port and at sea, before and after innovations are installed. All ships will be tested.

Cleanliness, appearance, and condition data will be recorded on the FM Inspection Form, Data Sheet 0-1B (figure 2-B).

Frequency of inspections and the selection of spaces to be inspected by test observers will be determined by the test director, who will ensure random selection of spaces. Data collection by FM supervisors and ship officers will be scheduled separately, and separate data analyses will be conducted.

*It is essential to note that the data collected and analyzed throughout this program be kept in strictest confidence. Rating data, when reported, will not refer to any of the ships by name or number or any other traceable identifier - they will be anonymous in all external communications.

Questionnaire data will also be collected to determine perceptions of effectiveness of the innovations. Data sheet O-1C (figure 3-B) will be used for this purpose.

III. Data Analysis.

1. FM Man-Hour Expenditures.

Weekly FM man-hour expenditures data will be computed for all ships. Data reliability will be estimated.

As can be seen from table 3-A, appendix A, three FF-1052 class ships will, by the end of the test program, have complete suits of FM innovations (SOE, MIM, and TTI). Additionally, all innovations will be installed on one of the LST-1179 class ships. One of the tests is concerned with the effect of all innovations combined. The other tests deal with the effect of each innovation class and all combinations. FM man-hour expenditure data will be compared in an analysis of variance to determine if the FM man-hour expenditures are significantly lower than for ships without innovation or for periods prior to installation of innovations. Scheffe's test will be used to determine the combinations that impact most on man-hour expenditure.* Gain scores will also be computed and analyzed to estimate the average expected savings due to FM innovations.

2. Cleanliness, Appearance, and Condition.

An estimate of data reliability will be computed. Analysis of variance will be used to determine if significant improvements in ratings, or lack of decline in ratings, are associated with the implementation of the FM innovations aboard selected ships. Scheffe's test will be used to determine the combinations that impact most on the ratings. Gain scores will also be computed on all rating data and analyzed to estimate the degree of improvement accrued from the implementation of the FM innovations.

Questionnaire data (figure 3-B) will also be analyzed to determine overall perception of cleanliness, appearance, and condition. A chi-square analysis of selected items on the questionnaire will be performed.

*Hays, W. L., Statistics for Psychologists, Holt, Chinehaul and Winston, N.Y., p. 484 (1965).

FACILITIES MAINTENANCE STUDY
DAILY TIME AND JOB TICKET

SHIP _____ DATE _____

FM SPVR _____
SIGNATURE

FM PERSONNEL ID _____
SIGNATURE

DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOR NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___
DATE	FM JOB NAME OR NUMBER	SPACE NAME or NO.	HOURS___ MIN ___

Figure 1-B
Data Sheet 01-A
Assignment Chit

FACILITIES MAINTENANCE
INSPECTION FORM

SHIP NAME & NUMBER: _____ DATE: _____

SHIP LOCATION: _____ TIME: _____

SHIP STATUS: ☐ IN-PORT; ☐ UNDERWAY OBSERVER: _____

SPACE: _____ SPVR: _____ DATE SET: _____

OVERALL APPEARANCE RATING (Check One)

☐ OUTSTANDING ☐ SATISFACTORY ☐ UNSATISFACTORY

PERFORMANCE RATING SCALE

EXCELLENT: NO MAINTENANCE NECESSARY — 1 — 2 — 3 — 4 — 5 — 6 — 7 — UNACCEPTABLE: COMPREHENSIVE FACILITIES MAINTENANCE ACTION REQUIRED, e.g., SURFACE RENEWAL

SPACE RATED	(Leave Blank) SURFACE TYPE	RATING	TYPE STANDARD USED
BULKHEAD:			
OVERHEAD:			
DECK:			

FIXTURES/EQUIPMENT RATED	RATING

COMMENTS (SPECIAL PROBLEMS): _____

Figure 2-B
Data Sheet 0-1B

INSTRUCTIONS FOR COMPLETING
DATA SHEET O-1B

QUALITY STANDARDS FOR JUDGING
FACILITIES MAINTENANCE PERFORMANCE

I. INTRODUCTION

The purpose of this document is to assist the observer using Data Sheet O-1B in evaluating the cleanliness and appearance of shipboard spaces in the Facilities Maintenance Demonstration Study.

In a sense, a recording of frequency of job performance is a measure of the level of housekeeping, e.g., a carpet vacuumed weekly. However, a host of other factors enter into the determination of level of housekeeping. These include: use of traffic conditions, procedures used, level of competence or training of the worker, materials and equipment used, type of soiling, etc.

It is assumed that these factors will operate on both the experimental ship and control ships in this study, and, where possible, these will be accounted for in analyses of data concerning level of facilities maintenance. The attempt here is to establish a common base, however arbitrary it may seem, for the evaluation and cleanliness of the surfaces and spaces included in this investigation.

The inspection forms make provisions for evaluating spaces and aspects of spaces on a judgment scale. These forms are check lists which show the observer/inspector what to evaluate and what numerical quality ratings are to be used. The remainder of this document presents verbal descriptions of quality standards which should aid the inspector/observer in determining how to evaluate appearance or quality.

II. STANDARDS

A. Mirrors, lockers, metal furniture, stainless steel surfaces, brightwork, enameled surfaces (urinals, commodes, basins).

Rating	Description
1	Dry, dust-free, smooth, shiny uniform surface, absence of streaks, water stains, films.
2	Wet, minor water streaking, surface appears not to be cleaned uniformly, slightly dull but no films, dust or stains. Records should indicate that for sanitary areas (heads, showers) application of detergent sanitizer was made less than 24 hours ago.

1

Figure 2-B (Cont)

Rating	Description
3	(20% or less of area examined.) Dust, streaked surface with light film, dull appearance, no stains, no caked soil, film easily removed with dry cloth.
4	(Between 40% and 20% of area examined.) Dust, streaked surface or water spots, soap building in soap containers, dull appearance, no caked soil or stains, film easily removed with dry cloth.
5	Fingerprints, greasy spots, dull or dusty overall appearance, wet slime or scum on surface, heavy streaking and/or water spotting, slightly caked soil, wiping with dry white cloth has relatively little effect to darken cloth. Heavy soap building, toothpaste spots.
6	Heavily caked soil, dried scum, slime noticeable, yellowish appearance, staining, darkened soil, heavy, greasy, dull appearance over significant areas.
7	Bad odor near surface, heavy caked soil and/or grease, dark stains, dark scum, etc.

B. Vinyl asbestos tile or terrazzo decks.

Rating	Description
1	New appearance, shiny, full of gloss.
2	Minor dust in low traffic areas, minor dullness in trafficked areas. Dust mopping will restore.
3	Streaks, slight film, slightly worn appearance, occasional scuff marks, but surface finish basically intact. Sweeping, damp swabbing will restore.
4	Heavy scuff marks, spots, grease spills, loose trash, grit on surface, generally dull, dirty appearance. Restorable through sweep, swab, and spray buff.
5	Worn traffic areas, grime, caked soil, grit and sand in corners, black scuff marks over significant portion of traffic areas. Yellowish stains. Sweep, swab, new coat of finish required.

Figure 2-B (Cont)

Rating	Description
6	Finish buildup in low traffic area, worn finish in heavy traffic areas, yellow stains, grease, dirt, grime over large area. Strip and refinish will restore.
7	In addition to 6 above, fresh oil or grease, slippery, wet surface, damaged basic surface. Removal and replacement required.

C. Carpeting/walk off mats (use new sample swatch if possible for visual standard).

Rating	Description
1	New appearance, colors bright, uniformly clean pile.
2	Heavy traffic areas show signs of slight dust and loose soil. Light traffic areas clean. Light vacuuming will restore.
3	Loose trash, bits of paper, etc dust over 20% of area inspected. Vacuuming will restore.
4	Same as 3 except occasional spots from spills. Vacuuming and spot removal will restore.
5	Heavy spots (crusted, darkened, dull, discolored pile in heavy traffic areas). Vacuuming and spot removal may restore - marginal.
6	Generally dirty, spotty appearance, grit embedded in pile, grease stains, etc. Shampoo and vacuuming will restore.
7	Damaged, dirty, caked pile. Pile badly worn, holes and fraying. Renewal required.

D. Painted surface (non-skid or steel decks, overheads and bulkheads, lagging, beams, angle iron, etc).

Rating	Description
1	Dust-free, no film, dirt, soil or grease visible. Surface uniform and no stains.
2	Light coat of dust visible, no film, oil, grease, water spots or streaks. Light dusting will restore.

Figure 2-B (Cont)

Rating	Description
3	In addition to dust, minor streaking or water spots and/or light film. Damp wiping will restore.
4	Heavy film, dust deposits, grime and soil. Washing with cloth and detergent will restore.
5	Stains, grease, oil, film and caked soil deposits (under 50% of total area). Combination of scrub/wash will restore.
6	Same as 5 but over 50% of area. Scrubbing entire surface will restore.
7	Rust, caked grease, soot or grime or damage over extensive portion of surface; surface renewal required to restore.

E. Overall space rating (see table 1).

Rating	Description
1	Less than 4 items failed.
2	Between 4-6 items failed.
3	Between 7-9 items failed.
4	Between 10-12 items failed.
5	Between 13-15 items failed.
6	Between 16-18 items failed.
7	Between 19-21 items failed.

TABLE 1
INSPECTION FACTORS

1. Deck protected, sealed and clean.
2. Carpets, mats clean.
3. Baseboards clean.
4. Bulkheads clean.
5. Overheads clean.
6. Furnishings & fixtures clean.
7. Doors & hatches clean (hardware incl).
8. Vents, pipes clean.
9. Light fixtures clean & operating properly.
10. Scuttlebutts clean.
11. Space free from odors.
12. Mirrors, urinals, commodes clean.
13. Washbowls clean.
14. Dispenser clean.
15. Buttkits empty and clean.
16. Trash receptacle clean and fresh liners inserted.
17. Dispenser filled.
18. Lockers clean.
19. Drains clear and clean.
20. Equipment/tools stored properly.
21. Ladders clean and dry.

Figure 2-B (Cont)

DATA SHEET O-1C

FACILITIES MAINTENANCE STUDY QUESTIONNAIRE

Instructions for Administering

This questionnaire has been developed to obtain information relating to Fleet acceptance of the facilities maintenance concepts being evaluated. The questionnaire has parts as follows:

Part A. General Information

Part A is to be completed by a designated observer during interview sessions with respondents. It contains all required identification data.

Part B. Overall Effectiveness

Part B contains two scales and is a self-administering device. The observer is to ensure that all respondents understand the purpose and mechanics of filling out this part and will collect the completed scales after allowing the respondent sufficient time to finish.

Part C. Suitability for Service Use

Part C is self-administering and contains provisions for open ended comments.

Figure 3-B
Facilities Maintenance Study Questionnaire

FACILITIES MAINTENANCE QUESTIONNAIRE

Part A. General Information

1. FMQ Serial No.: _____

2. Ship ID: _____

3. Test Observer: _____
(name) (org)

4. Date: _____ 5. Time: _____

6. Period Covered: _____
(from) (to)

7. Respondent ID: _____
(name) (rank)

8. Position Title of Respondent: _____
(department) (division) (function)

9. Length of Time on Board this Ship _____

Figure 3-B (Cont)

FACILITIES MAINTENANCE QUESTIONNAIRE

Part B. Overall Effectiveness (Self-Administering)

Instructions for Completing Part B

The scales in this part of the questionnaire have been developed to obtain information on the effectiveness of facilities maintenance performed aboard your ship. You are asked to judge facilities maintenance from two points of view:

1. Comparative scale-rate the effectiveness of each facilities maintenance aspect as it is now compared to what it was prior to the last three months.

2. Effectiveness scale-rate the effectiveness of each facilities maintenance aspect with regard to what you think it should be.

You are encouraged to add any comments which might aid in this evaluation in the space provided at the end of Part B.

Figure 3-B (Cont)

Part B

Comp Scale:

1	2	3	4	5
Seriously Degraded	Slightly Degraded	Same as Before	Slightly Improved	Greatly Improved

Eff Scale:

1	2	3	4	5
Grossly Ineffective	Slightly Ineffective	Moderately Effective	Very Effective	Exceptionally Effective

	Rating Scores	
	Comp	Eff
Surface preparation/corrosion control - overall		
Exterior - removal of coatings		
Exterior - application of coatings		
Interior - removal of coatings		
Interior - application of coatings		
Routine (daily/weekly) maintenance - overall		
Decks (sweeping, swabbing, vacuuming) - overall		
Heads		
Berthing area		
Primary work area (specify)		
Passageways		
Messing area		
Lounge (specify)		
Wardroom		
Galley/scullery		
Bulkheads (dusting, vacuuming, wiping, sanitizing) - overall		
Heads		
Berthing area		
Primary work area		
Passageways		
Messing area		
Lounge (specify)		

Figure 3-B (Cont)

Part B (Cont)

	Rating Scores	
	Comp	Eff
Wardroom		
Galley/scullery		
Overheads (dusting, vacuuming, wiping) - overall		
Heads		
Berthing area		
Primary work area		
Passageways		
Messing area		
Lounge (specify)		
Wardroom		
Galley/scullery		
Fixtures and furnishings (dusting, sanitizing, wiping, vacuuming) - overall		
Heads		
Berthing area		
Primary work area		
Passageways		
Messing area		
Lounge (specify)		
Wardroom		
Galley/scullery		
Periodic (monthly, quarterly, as required) - overall		
Deck stripping and refinishing		
Carpet shampooing/stain removal		
Bulkhead washdown		
Safety - overall		
Equipment		
Chemicals		
Procedures		
Electrical		
Fire		

Comments: _____

_____

_____

_____

_____

Figure 3-B (Cont)

FACILITIES MAINTENANCE QUESTIONNAIRE

Part C. Suitability for Service Use

Instructions for Completing Part C

Part C of this questionnaire has been developed to obtain information on the suitability of facilities maintenance on this ship. In filling out the questions, please be as specific as you can and feel free to suggest ways to improve the system. If you need clarification consult the Test Observer listed in Part A of this questionnaire.

Figure 3-B (Cont)

Part C

Indicate your opinion as to whether or not the following items are currently satisfactory aboard your ship and provide explanatory comments concerning specific deficiencies or methods of improvement where applicable. (Use additional sheets if required.)

1. Technical FM documentation (instructions, manuals, guidance documents, brochures, etc).

☐ Satisfactory
☐ Unsatisfactory
☐ Undecided

Comments: _____

2. Method of assigning FM work to ship force.

☐ Satisfactory
☐ Unsatisfactory
☐ Undecided

Comments: _____

3. Training on FM tasks.

☐ Satisfactory
☐ Unsatisfactory
☐ Undecided

Comments: _____

4. Manpower organization for FM performance.

☐ Satisfactory
☐ Unsatisfactory
☐ Undecided

Comments: _____

Figure 3-B (Cont)

Part C (Cont)

5. FM record keeping forms and procedures. ☐ Satisfactory ☐ Unsatisfactory ☐ Undecided

Comments: _____

6. Availability of FM equipment. ☐ Satisfactory ☐ Unsatisfactory ☐ Undecided

Comments: _____

7. Availability of FM consumables. ☐ Satisfactory ☐ Unsatisfactory ☐ Undecided

Comments: _____

8. Availability of sufficient personnel. ☐ Satisfactory ☐ Unsatisfactory ☐ Undecided

Comments: _____

9. FM management and inspection processes. ☐ Satisfactory ☐ Unsatisfactory ☐ Undecided

Comments: _____

Figure 3-B (Cont)

Part C (Cont)

10. Quality and timeliness of FM work.

☐ Satisfactory
☐ Unsatisfactory
☐ Undecided

Comments: _____

_____

_____

_____

11. Impact of existing FM requirements on other areas of work and training.

☐ Satisfactory
☐ Unsatisfactory
☐ Undecided

Comments: _____

_____

_____

_____

12. Safety in performing FM.

☐ Satisfactory
☐ Unsatisfactory
☐ Undecided

Comments: _____

_____

_____

_____

13. FM technical procedures and methods.

☐ Satisfactory
☐ Unsatisfactory
☐ Undecided

Comments: _____

_____

_____

_____

Figure 3-B (Cont)

TEST SEGMENT II

TESTS S-1 THROUGH S-5

Test S-1 Reliability

I. Purpose. To assess the reliability of the FMS equipment and materials in an operational Fleet environment.

II. Procedures. Operating time and failure data will be collected on all equipment used during the test program (all electric and air powered equipment will have operating time meters installed). Mean-times-between-failures will be computed for each type of equipment installed.

The reliability of the equipment is based on total elapsed operating hours completed between critical failures. For purposes of computing reliability/maintainability data, a critical failure is one which prevents the equipment from providing any assistance in performing FM functions.

Loss of electrical power, air pressure, or water sources, where applicable, or lack of consumable products will not be considered an equipment failure.

This test consists of: (1) operating the equipment as many hours as required for accomplishment of FM work; (2) collecting operating hours, failure information, and computing MTBF for each type of equipment; (3) analyzing each failure to determine the operational impact of the failure (e.g., the need to use more conventional of time consuming procedures); (4) investigating the failures to the extent possible and categorizing them as design deficiencies, random, or due to improper use or maintenance; and (5) investigating and recording other features of design, installation, operation, or maintenance which are found to affect reliability.

An equipment test log will be completed for all equipment by FM and/or repair personnel. All information will be recorded as soon as possible after it is obtained. Data sheet S-1 (figure 4-B) will be used to collect quantitative data for computing reliability estimates.

III. Data Analysis. A point estimate of MTBF will be computed as follows:

$$\text{MTBF} = \frac{\text{total equipment operating time (for a particular type of equipment)}}{\text{number of failures}}$$

The lower MTBF confidence limit at a 90% confidence level will be estimated from the total system operating time, total number of failures, and an exponential distribution.

Failures will be categorized as to component failure, design deficiencies, or improper use or maintenance.

Analysis will include a qualitative assessment of the data and comments recorded on all aspects of design, installation, operation, or maintenance.

Test S-2 Maintainability

I. Purpose. Assess maintainability of the FM equipment/materials in an operational Fleet environment.

II. Procedures. There are two areas of interest in this test: (1) collecting maintenance actions data to compute mean-time-to-repair, maintenance support index, and maximum time to repair and (2) investigating the adequacy of recommended preventive maintenance (where applicable) including periodicity and time to perform. During the initial period following installation, contractor personnel will provide assistance when shipboard personnel do not have sufficient experience to maintain the equipment. Data sheet S-1 will be used to collect data for this test.

III. Data Analysis.

1. Calculation: MTTR. Summation of active repair time due to failure during a given period divided by total number of failures:

$$\text{MTTR} = \frac{\text{active repair time}}{\text{number of failures}}$$

MSI is the total number of maintenance man-hours for preventive and corrective maintenance required to support each hour of operational use.

$$\text{MSI} = \frac{\text{total hours of equipment operated}}{\text{total number of maintenance man-hours (CM \& PM)}}$$

2. Assessment will be made of the efficiency and effectiveness of preventive maintenance procedures listed in technical documentation.

3. Analysis will include a qualitative assessment of the data and comments recorded for any features of design, installation, operation, or support, which are noted to affect maintainability.

Test S-3 Equipment/Materials Availability

I. Purpose. To determine the availability of the FMS equipment/materials in an operational environment.

II. Procedures. This test consists of collecting operational demand time and all downtimes throughout the entire evaluation and computing operational availability.

Operational demand time is the total time during which FM equipment/materials are required to be used.

Downtime is that portion of operational demand time during which the equipment or material is not capable of use for any reason (except use on a different task). Data sheet S-1 will be used to collect these data.

III. Data Analysis.

Operational Availability. The probability that a given piece of equipment will operate to specified minimum performance standards at any given time. This quantity accounts for all maintenance actions as well as maintenance delays. It may be expressed:

$$AO^{*} = \frac{\text{operational demand time - downtime}}{\text{operational demand time}}$$

Test S-4 Supportability

I. Purpose. Assess supportability of the FMS in an operational Fleet environment.

II. Procedures. This test will be conducted concurrent with other S and H tests and consists of:

- Validating the accuracy, completeness, and usefulness of the operating and technical manuals and training provided.

*For each piece of equipment.

- Evaluating the FM procedures.

- Noting any special requirements for shore or contractor services.

- Assessing logistic support requirements.

- Recommending type and number of repair parts and consumables which should be carried aboard and/or in the supply system.

The facilities maintenance study questionnaire (figure 3-B) and data sheet S-1 will be used to collect these data.

III. Data Analysis.

A qualitative assessment will be made regarding personnel supportability based on adherence to FM schedules and questionnaire results recorded for this test. A qualitative assessment will be made regarding adequacy of:

- TII.

- MIM.

- Equipment/materials.

- Technical procedures.

- Administrative burden.

Test S-5 Compatibility

I. Purpose. Assess the compatibility of equipment/materials and manpower management concepts with existing shipboard facilities and divisional responsibilities.

II. Procedures. This test will be conducted throughout the evaluation by making observations during in-port and at-sea operations involving FM work. Areas to be investigated include:

1. Ship energy and water resources for equipment operation.

2. Work demands (other than FM) and other categories of man-hour expenditures (e.g., division training) placed on FM personnel.

The facilities maintenance questionnaire (figure 5-B) will be used to collect these data.

III. Data Analysis.

A qualitative assessment will be made of the compatibility of the FMS with shipboard environment. The assessment will be based on the total results and comments recorded during testing which note an effect on compatibility.

FMS Test Project

Maintenance Actions of FM Equipment
Data Sheet S-1

Ship: _____

Sheet No.: _____

Date: _____

Observer : _____

1. Type of Action: PM _____ CM _____
2. Time of failure or start of PM: _____
3. Equipment ID (including serial number): _____
4. Equipment Operating hours: _____
5. Description of Maintenance Action: _____

_____

_____

6. Technician Rate/Rating: _____
7. Time to fault isolate: Hours _____ Min ___ Time to repair: Hrs ___ Min _____
8. Active maintenance time: Hours _____ Min _____
9. First symptom(s) of failure _____

_____

10. Cause of failure: _____

_____

11. Tools/Parts used: _____

_____

12. Discuss adequacy of training for performing maintenance: _____

_____

_____

13. Problems in Performing maintenance: _____

_____

_____

Figure 4-B
FMS Test Project
Maintenance Actions of FM Equipment
Data Sheet S-1

TEST SEGMENT III

TESTS H-1 THROUGH H-3

Test H-1 Safety

I. Purpose. Determine if FM equipment and materials can be safely used and handled.

II. Procedures. Safety characteristics and potential hazards will be analyzed and will be assessed at the David W. Taylor Naval Ship Research and Development Center. Additionally, questionnaire data will be collected from the facilities maintenance study questionnaire (figure 3-B). Respondents will include:

- The ship's safety officer.
- The ship's medical personnel.
- FM work supervisors.
- Personnel assigned to FM work.

III. Data Analysis. In addition to the DTNSRDC safety analysis report, a qualitative assessment of questionnaire results will be made to identify potential safety problems.

Test H-2 Personnel and Training

I. Purpose. Determine skill and knowledge level and training required to operate and maintain FM equipment and materials.

II. Procedures. Skill levels of personnel performing FM will be a matter of record. Training will be assessed by using a skill and knowledge paper-and-pencil test (figure 5-B) and the facilities maintenance study questionnaire (figure 3-B).

III. Data Analysis. A qualitative assessment of questionnaire data will be performed to estimate skill level and training requirement. Test results will be analyzed by using analysis of variance and gain score* techniques to estimate if effects of innovations led to increased skill and knowledge and to estimate degree of improvement.

*A gain score is the difference between the score on a test obtained on the last administration and the one obtained on a previous administration.

Test H-3 Human Engineering

I. Purpose. Assess the adequacy of equipment, training, and management system design for operability and maintainability.

II. Procedures. Questionnaire data (figure 3-B) and data from other data sheets already discussed will be examined.

III. Data Analysis. A qualitative assessment of data will be made to assess operability and maintainability.

Instructions

You will have 50 minutes to complete this test. If you do not understand a question, go on to the next one. Return to incompleted questions later.

For the multiple-choice question or true-false question, you are to mark the appropriate area of the answer sheet. Go through the sample items below now to make sure that you understand how to mark your answers.

1. Which of the following places is subject to the accumulation of water?

a. Sumps
b. Bilges
c. Tank tops
d. Bottom sections of machinery spaces
e. All of the above

The correct answer to question 1 is "e. all of the above." Therefore, the mark on the answer sheet would be placed under "e."

Please mark only one block and make your marks heavy under the answer that is best suited for the question. If you must erase, do it completely.

Do the next sample question to be sure you understand the method of marking your answer:

(Use the practice block in the upper right-hand portion of the answer sheet.)

2. Facilities maintenance includes surface preparation, corrosion control, painting, and maintaining cleanliness and appearance.

a. True
b. False

There are 100 questions in this test. Do not begin until you are told to do so by the test administrator.

Figure 5-B
Facilities Maintenance
Skill and Knowledge Test

1. Rust stains which appear on sound paintwork, only require that the surface be washed with warm soapy water or detergent, rinsed with fresh water and dried.

a. True
b. False

2. Men to be employed in cleaning fresh water tanks should

a. Wear auxiliary breathing devices
b. Be examined by a Medical Officer
c. Take frequent breaks
d. All of the above

3. When stripping a deck it is essential to

a. Use a steel wire brush to get to areas not accessible with a scrubber
b. Remove all wax residue
c. Use undiluted stripping solution
d. None of the above

4. In cleaning furniture in mess deck areas it is recommended that you use a cloth to brush dried food residue to the deck.

a. True
b. False

5. Leftover deck finish should be returned to its original container.

a. True
b. False

6. Stainless steel surfaces in the head should be dried with squeegee or cloth.

a. True
b. False

7. A deck finished with metallized acrylic is more slippery than a waxed deck.

a. True
b. False

8. In cleaning heads and showers, the lavatory area should be cleaned last.

a. True
b. False

Figure 5-B (Cont)

9. Galvanized steel surfaces should be cleaned with a wire brush.

a. True
b. False

10. When ladder treads become very dirty they should be cleaned with

a. A wire brush
b. Scrub brush
c. Swab
d. Steel wool

11. Glass surfaces should be spot cleaned with

a. Cleaner
b. Regular glass cleaner
c. Soapy water
d. Vinegar and water

12. Many thin coats of deck finish do a better job than fewer thick coats.

a. True
b. False

13. When cleaning passageways, you should secure the passageway with lines to prevent people from walking through the work area.

a. True
b. False

14. It is best to loop the cord of your scrubbing machine around your shoulder or body to avoid tangling.

a. True
b. False

15. Separate cleaners and disinfectants should not be mixed together because

a. It is best to disinfect and clean in separate operations
b. It may cause release of toxic substances
c. This mixture will result in excessive suds
d. The cleaner may neutralize the disinfectant

16. A mirror is a good tool for checking head sanitation.

a. True
b. False

Figure 5-B (Cont)

17. To thoroughly wet the strands of your swab with floor finish will take about

a. 2 ounces of finish
b. One pint of finish
c. One quart of finish
d. One and one-half quarts of finish

18. Electrical rubber gloves should be worn when using electrical equipment such as a floor machine

a. To prevent electrical shock
b. To reduce vibration from the machine on the operator's arm
c. To protect the operator from bacteria
d. None of the above

19. Floor machines should be cleaned once a month to remove wax and other cleaning chemical stains.

a. True
b. False

20. Fire hoses located on the main deck may be used for salt water washdowns.

a. True
b. False

21. Debris and particles from the stack which land on deck

a. Should be removed from the deck as soon as possible
b. Will stain and damage vinyl awnings and canvas work
c. Are extremely corrosive when mixed with standing water
d. All of the above

22. Immediately upon skin contact with acids

a. Report to sick call
b. Wipe the acid off
c. Wash with a flood of water
d. Apply bandage

23. Soap buildup in the shower stalls will serve as a breeding area for bacteria.

a. True
b. False

Figure 5-B (Cont)

24. Aluminum alloys used for ship structures form a thin skin over their entire surface; therefore, pitting cannot get started.

a. True
b. False

25. A bowl mop should be used to clean under the flushing rim of a urinal to remove buildup which may lead to bacteria growth.

a. True
b. False

26. When standing water is left on the exterior decks, there is a greater possibility that corrosion will occur and will damage the surface.

a. True
b. False

27. Oil spills on deck

a. Are a safety hazard
b. Should be cleaned with an oil remover agent
c. Can destroy the effectiveness of deck tread and safety tread
d. All of the above

28. An alkali such as heavy duty cleaning soap powder should be used for cleaning aluminum and other structural materials.

a. True
b. False

29. Electrical equipment should be checked by a qualified electrician for proper operation and ground

a. Daily
b. Weekly
c. Biweekly
d. Monthly

30. When preparing to apply a new finish to a vinyl asbestos tile deck, plan to put into the bucket

a. Exactly the amount that you expect to use
b. Just a little less than you expect to use
c. Just a little more than you expect to use
d. 1/2 of the amount you need

Figure 5-B (Cont)

31. After you have stripped a resilient deck, plan to apply

a. Heavy duty detergent
b. One coat of finish
c. Two coats of finish
d. Descaling compound

32. Procedures and materials used in waxing, stripping, and buffing are the same for vinyl asbestos tile as they are for terrazzo deck material.

a. True
b. False

33. You should, upon detecting defects in electrical parts of your equipment,

a. Make immediate repairs
b. Exchange the equipment
c. Report to your supervisor
d. Continue until the job is finished and make report when returning equipment

34. Pouring deck finish back into its drum can cause the contents of the entire drum to spoil.

a. True
b. False

35. Mixing bleach with ammonia produces

a. An explosion
b. An effective cleaner
c. Chlorine gas
d. A blue liquid

36. All paints deteriorate with age.

a. True
b. False

37. When using a floor machine, one should raise the handle to go to the left and lower the handle to go to the right.

a. True
b. False

Figure 5-B (Cont)

38. Darkening of deck tile

a. Is caused by a buildup of successive layers of wax mixed with soil
b. Is prevalent around baseboards and furniture
c. Is the result of improper floor care techniques
d. All of the above

39. Running rust is caused by

a. Galvanic action at the location of the rust stain
b. Corrosion underneath the painted surface
c. Rust washing down from corroded steel at a higher level
d. All of the above

40. When applying deck finish, bubbling or milky appearance means

a. Too much finish in the swab
b. Too little finish in the swab
c. The solution is too cold
d. The solution is too hot

41. When cleaning lavatory areas, it is best to start with

a. Deck
b. Commodes
c. High ledges
d. Pipes under basins

42. The best way to clean rust streaks in the commode is to use

a. Scouring powder
b. Wire brush
c. Porcelain descaling compound
d. Steel wool pads

43. If your carpet shampoo machine is hard to hold back, the brush is set

a. Too deep
b. Too shallow

44. Agitation of carpet shampoo solution prior to filling the tank of the carpet shampoo machine is recommended.

a. True
b. False

Figure 5-B (Cont)

45. Which of the following stains/spots on carpets should be treated with hot water?

a. Soft drinks
b. Coffee or tea
c. Oil or grease
d. Paint

46. Shampoo solution should not be stored in the tank of the carpet shampoo machine.

a. True
b. False

47. Select the answer which indicates the best sequence of steps for spot-cleaning carpet.

a. Apply carpet stain remover, pick up excess with scraper or dustpan, apply water from spray bottle, vacuum.
b. Apply water from spray bottle, pick up excess with scraper or dustpan, apply carpet stain remover, vacuum.
c. Vacuum, apply carpet stain remover, pick up excess with scraper or dustpan, apply water from spray bottle.
d. Pick up excess with scraper or dustpan, apply carpet stain remover, apply water from spray bottle, vacuum.

48. At intervals the following items should be cleaned with descaling chemicals

a. Electrical outlets
b. Pipes under basins
c. Commodes and urinals
d. Shower stalls

49. Which of the following is not required for proper carpet shampooing?

a. Carpet vacuum
b. Foam shampooer
c. Scrub brush
d. Heavy duty detergent

50. When cleaning a water soluble spot from a carpet, use a wet sponge and

a. Work from the edges of the spill to the middle
b. Work from the middle of the spill to the edges

51. A broom or brush should not be used to clean the edge of carpeting adjacent to bulkheads.

a. True
b. False

Figure 5-B (Cont)

52. If a spot on the carpet appears oily or it is known to be oily, begin treating the spot with

a. Hot water
b. Cool water
c. Stain remover
d. Heavy duty detergent

53. After stripping, terrazzo decks generally require

a. Two coats of finish
b. Four coats of finish
c. Three coats of finish
d. Six coats of finish

54. A spray buffing pad can be cleaned by pulling the center of the pad out and using it as a brush.

a. True
b. False

55. It is most effective to pick up stripper and old finish using:

a. Toweling or dry cloths
b. An upright vacuum cleaner
c. A wet vacuum
d. Swab and bucket with wringer

56. Porcelain descaling compound should not be used in urinals and toilets more frequently than once per week.

a. True
b. False

57. Carpeted deck sections close to bulkheads and furnishings:

a. Should be spot cleaned frequently
b. Tend to collect soil to a greater extent than main traffic areas
c. Will not need to be vacuumed as thoroughly as will main traffic patterns
d. Should be cleaned last

58. When cleaning dust and dirt on angle iron, cable ways, etc it is best to begin by using

a. A vacuum cleaner with pipe cleaning tool
b. Water, detergent and c'eaning cloth
c. A wire brush and steel wool
d. None of the above

Figure 5-B (Cont)

59. An efficient method of routine maintenance for finishes on terrazzo and vinyl asbestos tile is

a. Spray buffing
b. Stripping
c. Weekly coats of additional finish
d. Frequent scrubbing

60. "Striping" refers to

a. Method of vacuuming NOMEX carpets
b. Method of applying deck finish
c. Method of cleaning glass
d. Method of descaling commodes

61. A wet vacuum must be prepared for wet pick-up by

a. Cleaning the moleskin filter
b. Inserting the wet pan
c. Changing the hose attachments
d. Removing the casters

62. For good carpet maintenance, the best way to handle spot-cleaning is

a. To allow the spot or soil to dry completely before cleaning
b. To follow a monthly routine of thorough carpet shampooing
c. To apply fresh water to a spot, working from the edges toward the middle
d. To clean the spot as soon as heavy soiling occurs

63. After stripping solution has been applied to the deck

a. The deck should be scrubbed immediately
b. It should be allowed to dissolve the old finish for 5-10 minutes
c. It should be allowed to dissolve the old finish for 15-30 minutes
d. It should be allowed to dry before proceeding to the next step, which is application of the new finish

Figure 5-B (Cont)

64. Lavatory fixtures (sinks and faucets) should be routinely cleaned using

a. Cleanser and brush
b. Steel wool and soap
c. Heavy duty detergent solution and cloth
d. Detergent sanitizer solution, spray bottle and cloth

65. Pipes under basins in the lavatory area should be cleaned

a. With descaler
b. Once each month
c. With a wirebrush
d. Daily

66. Brooms should be stored vertically with the fiber end down.

a. True
b. False

67. To identify an unlabeled substance in a container it is best to

a. Smell it
b. Taste it
c. Try using it in an inconspicious place
d. None of the above

68. The importance of keeping a clean ship is to

a. Improve safety, protect ship's material condition, pass inspection
b. Improve morale, pass inspection
c. Improve morale, maintain a safe healthy environment, protect material condition, pass inspection
d. None of the above

69. Floor scrubbing equipment is easiest to clean

a. Immediately after use
b. After stripping solution is dry
c. With descaling compound
d. With a scraper

70. The same side of a straw broom should always be used.

a. True
b. False

Figure 5-B (Cont.)

71. Emptying and cleaning buttkits is one of the first things to be done in cleaning office spaces.

a. True
b. False

72. Navy paints are designed such that salt spray does not cause any damage to the paint.

a. True
b. False

73. In order to prevent buildup when applying deck finish

a. The floor machine should be operated in the high speed mode
b. Use the blue pad on the floor machine
c. Use the striping technique
d. All of the above

74. The proper way to get dust off an uneven surface is to blow it off using the exhaust from a vacuum cleaner and then sweep it up.

a. True
b. False

75. The proper way to remove a plug from a receptacle is to

a. Wear gloves
b. Pull the cord gently
c. Grasp the plug itself
d. Grasp the cord and whip it out of the receptacle

76. Cleaning the baseboards can be made easier by using

a. Proper mopping techniques
b. Proper buffing techniques
c. A doodlebug or baseboard tool
d. All of the above

77. Using a floor machine in an open deck area you should try to swing an arc of

a. Less than 2 feet
b. Up to 6 feet
c. 6-10 feet
d. More than 10 feet

Figure 5-B (Cont)

78. In scrubbing a deck area next to a bulkhead with a floor machine, make the first pass

a. From right to left parallel to the bulkhead
b. From the bulkhead toward the center of the deck
c. In a figure eight
d. From left to right parallel to the bulkhead

79. Powdered abrasive cleansers are not recommended for routine cleaning of terrazzo decks

a. True
b. False

80. Which one of the following statements is <u>not</u> a correct procedure for using chemicals?

a. Read and follow directions
b. Always dilute chemicals before using
c. Use the right chemical for a given job
d. Change solution as often as necessary

81. Extra finish should be applied to deck area where tile has lifted or is missing.

a. True
b. False

82. Bulkheads should be wet/damp cleaned

a. From the top down
b. From the bottom up
c. From left to right
d. From right to left

83. Once stripping solution has been applied to an area and starts to dry

a. The area should be spray buffed
b. The final finish should be applied
c. More stripping solution should be applied
d. The area should be wiped with a clean damp cloth

84. When stripping solution has been splashed onto a bulkhead

a. It should be removed with a clean, damp cloth
b. It should be removed with a squeegee
c. It should be rinsed with fresh water and wiped dry
d. It should be allowed to dry before removing

Figure 5-B (Cont)

85. Stripping solution tends to remove a little bit of life from the decks each time it is used.

a. True
b. False

86. Cleaning chemicals should be diluted

a. By adding concentrate to the water
b. By adding water to the concentrate

87. Lacquered brightwork should be

a. Cleaned with a dry or damp cloth
b. Polished using Brasso or Noxon
c. Rubbed with lacquer rubbing compound
d. Cleaned with a powdered cleanser

88. Cleaning carpets with carpet shampoo improves appearance and prolongs carpet life.

a. True
b. False

89. Vinyl asbestos tile decks in moderate traffic areas, e.g., living spaces, will require stripping and recoating no more frequently than

a. Once per week
b. Once every two weeks
c. Once per month
d. Once per quarter

90. A blue pad should be used on the rotary floor machine for

a. Application of finish
b. Buffing
c. Polishing
d. Scrubbing

91. If paint is in poor condition - cracked, flaking off, or blistered - the whole area should be cleaned down to bare metal and a new paint film applied.

a. True
b. False

92. Weather decks and structures are most efficiently cleaned with

a. Scrub brushes, detergents and wet vacuum cleaners
b. Pressure washers
c. Swabs and buckets
d. Brooms and dust pans

Figure 5-B (Cont)

93. On galvanized or zinc-sprayed steel and aluminum surfaces, the following tools are recommended

a. Chipping hammers
b. Rotary peening devices
c. Wire brushes
d. None of the above

94. The most efficient tool(s) for removing standing water from irregular deck surfaces is

a. Straw broom and dry cloths
b. Squeegee
c. Sponge
d. Wet/dry vacuum cleaner

95. A brown pad should be used on the rotary floor machine for

a. Application of finish
b. Buffing
c. Polishing
d. Scrubbing

96. The rate of corrosion for two different metals touching each other

a. Is less than that of two identical metals touching each other
b. Is more than that of two identical metals touching each other
c. Is not different than that of two identical metals touching each other

97. Stainless steel cannot corrode.

a. True
b. False

98. Before returning furniture to a damp, freshly shampooed carpet

a. Equipment should be cleaned and stowed and checked for electrical safety. The tank of the shampooer should be emptied.
b. Pieces of brown wrapping paper should be positioned where the furniture will contact the carpet.
c. The space should be secured with a "Caution Wet Deck" sign, not with line.
d. The furniture should be cleaned with a vacuum cleaner or damp cloth and light detergent solution.

Figure 5-B (Cont)

99. The most expensive part of shipboard cleaning and housekeeping is

a. Good commercial equipment
b. Consumable products (solvents, finishes, detergents, paint)
c. Manpower
d. Good commercial equipment and consumable products

100. When using a floor machine one should raise the handle to go to the right and lower the handle to go to the left.

a. True
b. False

Figure 5-B (Cont)

TEST SEGMENT IV

TESTS D-1 THROUGH D-9

I. Purpose. To assess the design characteristics of the following:

- Pressure Washer System (D-1).
- Wet Vacuum (D-2).
- Papoose Vacuum (D-3).
- Carpet Shampooer (D-4).
- Rotary Peening Devices (D-5).
- Rotary Floor Machine (D-6).
- FMJIC's and Schedules (D-7).
- Training Program Modules (D-8).
- Technical Manuals (D-9).

II. Procedures. Questionnaires will be administered to personnel having direct experience with the items (figures 6-B thru 11-B and figure 3-B).

III. Data Analysis. A qualitative assessment of questionnaire results will be performed, and design recommendations will be examined and reported upon.

Instructions

This questionnaire has been prepared to collect information from you on facilities maintenance equipment that is being used in the Facilities Maintenance Study. Your answers will be held in strict confidence by the facilities maintenance study group and will not have any effect on your present shipboard assignment, your qualifications for advancement, or your Navy career.

This questionnaire has three sections:

1. In the first section you are asked to rate some aspects of the FM equipment.

2. In the second section you are asked questions about specific features of the FM equipment.

3. In the third section you are asked to give any additional information that may be helpful to the study team.

Feel free to ask questions at any time.

Figure 6-B
FM Equipment Questionnaire on Vacuum Cleaner (Wet/Dry Floor Model)

FM Equipment Questionnaire
on
Vacuum Cleaner (Wet/Dry Floor Model)

I. General Information

Ship: _____ Name: _____

Date: _____ Rate/Rating: _____

Interviewer: _____ Primary Duty: _____

Division: _____

What kind of training have you received on this equipment:

Contractor _____ OJT _____ Module _____

How often have you used this equipment? Very Little __ Some __ A Lot __

II. Vacuum Cleaner (Wet/Dry Floor Model) Questionnaire

A. Section I (Circle your rating choice)

1. In general, how well do you think the wet/dry vacuum performs?

1	2	3	4	5
Very Poorly	Fairly Poorly	Satisfactorily	Fairly Well	Very Well

2. Rate the following in combination with the wet/dry machine.

a. Power Wand on carpets	1	2	3	4	5
b. Wide mouth tool on decks	1	2	3	4	5
c. Wide mouth tool on bulkheads	1	2	3	4	5
d. Wet pickup squeegee on decks	1	2	3	4	5

3. How often did the wet/dry fail when you tried to use it?

1	2	3	4	5
Always	Often	Sometimes	Seldom	Never

4. How easy was the wet/dry vacuum equipment to use?

1	2	3	4	5
Very Hard	Fairly Hard	Moderately	Fairly Easy	Very Easy

Figure 6-B (Cont)

B. Section II (Circle One)

1. Is the tip-and-pour feature desirable? YES NO
If no, explain. _____

2. Are the locking casters satisfactory? YES NO
If no, explain. _____

3. Can this equipment be maneuvered satisfactorily? YES NO
If no, explain. _____

4. Can this equipment be carried between decks, etc without problems? If no, explain YES NO
_____

5. Does the automatic vacuum shut off work satisfactorily?
If no, explain. _____

6. Is the noise level satisfactory? YES NO
If no, explain. _____

7. Is the amount of suction satisfactory? YES NO
If no, explain. _____

8. Is the equipment worth using in order to save time or or labor? (Consider what is required to set it up or tear it down) If no, explain specific problems. YES NO
_____

9. Can you easily operate this equipment while the ship is underway ? If no, explain. YES NO
_____

10. Is the operation of the system easy to learn? If no, please comment YES NO
_____

C. Section III

1. What other problems in using the equipment did you find? Please indicate which tools, which surfaces, and which wet or dry functions are involved.

2. What features of the equipment do you especially like?

2

Figure 6-B (Cont)

Instructions:

This questionnaire has been prepared to collect information from you on facilities maintenance equipment that is being used in the Facilities Maintenance Study. Your answers will be held in strict confidence by the facilities maintenance study group and will not have any effect on your present shipboard assignment, your qualifications for advancement, or your Navy career.

This questionnaire has three sections:

1. In the first section you are asked to rate some aspects of the FM equipment.

2. In the second section you are asked questions about specific features of the FM equipment.

3. In the third section you are asked to give any additional information that may be helpful to the study team.

Feel free to ask questions at any time.

Figure 7-B
FM Equipment Questionnaire on Portable
Vacuum Cleaners (Papoose)

Data Sheet D-3

FM Equipment Questionnaire
on
Portable Vacuum Cleaners (Papoose)

I. General Information

Ship: _____ Name: _____

Date: _____ Rate/Rating: _____

Interviewer: _____ Primary Duty: _____

Division: _____

What kind of training have you received on this equipment?

Contractor _____ OJT _____ Module _____

How often have you used this equipment? Very Little __ Some __ A Lot __

I. Portable Vacuum Cleaners (Papoose) Questionnaire

A. Section I (Circle your rating choice)

1. In general how well do you think the papoose vacuum equipment performs?

1	2	3	4	5
Very Poorly	Fairly Poorly	Satisfactorily	Very Well	Very Well

2. Using the same scale as above, rate the following attachments.

a. Power wand on carpets	1	2	3	4	5
b. Wide mouth tool on decks	1	2	3	4	5
c. Wide mouth tool on bulkheads	1	2	3	4	5
d. Crevice tool	1	2	3	4	5
e. Round dusting tool	1	2	3	4	5
f. Pipe cleaning attachments	1	2	3	4	5

3. How often did the papoose vacuum equipment fail when you tried to use it?

1	2	3	4	5
Always	Often	Sometimes	Seldom	Never

Figure 7-B (Cont)

4. How easy was the papoose vacuum equipment to use?

1	2	3	4	6
Very Hard	Fairly Hard	Moderately	Fairly Easy	Very Easy

B. Section II (Circle One)

1. Is the papoose vacuum "backpack" feature convenient? YES NO
_____
_____

2. Is the two wheeled dolly satisfactory? If no, explain. YES NO
_____
_____

3. Are the attachments used with the papoose sufficient? YES NO
If no, explain. _____
_____

4. Is the amount of suction satisfactory? If no, explain. YES NO
_____
_____

5. Is the collector bag easy to replace or clean? If no, YES NO
explain. _____
_____

6. If disposable paper collector bags were used, were YES NO
they satisfactory? If no, explain. _____
_____

7. Is the noise level satisfactory? If no, explain. YES NO
_____
_____

8. Do the "snap on and off" connections work satisfactor- YES NO
ily? If no, explain. _____
_____

9. Is the equipment easy to set up, break down, clean YES NO
and stow? If no, explain specific problems.
_____
_____

10. Is the equipment worth using in order to save time or YES NO
labor? (Consider what is required to set it up or
tear it down.) If no, explain. _____
_____

Figure 7-B (Cont)

11. Can you easily operate the papoose while the ship is underway? If no, explain. _____ YES NO

_____

12. Is the operation of the papoose system easy to learn? If no, please comment. _____ YES NO

_____

13. Is the operations manual satisfactory? If no, please comment. _____ YES NO

_____

C. Section III

1. What other problems in using the equipment have you experienced?

2. What features of the equipment do you especially like?

Figure 7-B (Cont)

Instructions:

This questionnaire has been prepared to collect information from you on facilities maintenance equipment that is being used in the Facilities Maintenance Study. Your answers will be held in strict confidence by the facilities maintenance study group and will not have any effect on your present shipboard assignment, your qualifications for advancement, or your Navy career.

This questionnaire has three sections:

1. In the first section you are asked to rate some aspects of the FM equipment.

2. In the second section you are asked questions about specific features of the FM equipment.

3. In the third section you are asked to give any additional information that may be helpful to the study team.

Feel free to ask questions at any time.

Figure 8-B
FM Equipment Questionnaire on
High-Pressure Washer System

FM Equipment Questionnaire
on
High Pressure Washer System

I. General Information

Ship: _____ Name: _____

Date: _____ Rate/Rating: _____

Interviewer: _____ Primary Duty: _____

Division: _____

What kind of training have you received on this equipment?

Contractor _____ OJT _____ Module _____

How often have you used this equipment? Very Little __ Some __ A Lot __

1. High Pressure Washer System Questionnaire

A. Section I (Circle your rating choice)

1. In general, how well do you think the high pressure washer cleaned?

1	2	3	4	5
Very Poorly	Fairly Poorly	Satis-factorily	Fairly Well	Very Well

2. Using the same scale as above, rate how well the high pressure washer cleaned in the following instances:

a. Ordinary surface dirt	1	2	3	4	5
b. Bilge and oily surfaces	1	2	3	4	5
c. Badly fouled surfaces	1	2	3	4	5

3. How often did the high pressure washer fail when you tried to use it?

1	2	3	4	5
Always	Often	Sometimes	Hardly Ever	Never

4. How easy was the high pressure washer to use?

1	2	3	4	5
Very Hard	Fairly Hard	Moderately	Fairly Easy	Very Easy

Figure 8-B (Cont)

B. Section II

Circle One

1. Is the spray wand satisfactory? YES NO
   If no, explain. _____

2. Are the storage reels satisfactory? YES NO
   If no, explain. _____

3. Are the quick disconnect hose sections easy to assemble and disassemble? YES NO
   If no, explain. _____

4. Does the motor operate without problems? YES NO
   If no, explain. _____

5. Has the use of salt water been a problem? YES NO
   If no, explain. _____

6. Are the locations of the pumps and reels satisfactory? YES NO
   If yes, explain. _____

7. Are the jet nozzles satisfactory? YES NO
   If no, explain. _____
   Which jet nozzles are the most effective? _____

8. Has oil leakage occurred? YES NO
   If yes, give details. _____

9. Does priming the pump present a problem? YES NO
   If yes, explain. _____

10. Is the pressure output satisfactory? YES NO
    If no, explain. _____

11. Is the equipment easy to set up, breakdown and stow? YES NO
    If no, explain. _____

12. Is the equipment worth using in order to save time or labor? YES NO
    If no, explain. _____

13. Is the operation of the system easy to learn? YES NO
    If no, please comment. _____

Figure 8-B (Cont)

14. Is the operations manual satisfactory? YES NO
If no, please comment. _____

C. Section III

1. What other problems in using the equipment have you experienced?

2. What features of the equipment do you especially like?

Figure 8-B (Cont)

Instructions

This questionnaire has been prepared to collect information from you on facilities maintenance equipment that is being used in the Facilities Maintenance Study. Your answers will be held in strict confidence by the facilities maintenance study group and will not have any effect on your present shipboard assignment, your qualifications for advancement, or your Navy career.

This questionnaire has three sections:

1. In the first section you are asked to rate some aspects of the FM equipment.

2. In the second section you are asked questions about specific features of the FM equipment.

3. In the third section you are asked to give any additional information that may be helpful to the study team.

Feel free to ask questions at any time.

Figure 9-B
FM Equipment Questionnaire on
Carpet Shampooer

Data Sheet D-4

FM Equipment Questionnaire
on
Carpet Shampooer

I. General Information

Ship: _____ Name: _____

Date: _____ Rate/Rating: _____

Interviewer: _____ Primary Duty: _____

Division: _____

What kind of training have you received on this equipment?

Contractor _____ OJT _____ Module _____

How often have you used this equipment?

Very Little _____ Some _____ A Lot _____

II. Carpet Shampooer Questionnaire

A. Section I (Circle your rating choice)

1. In general, how well do you think this carpet shampooer cleaned?

1	2	3	4	5
Very Poorly	Fairly Poor	Satisfactorily	Fairly Well	Very Well

2. How often did carpet shampooer fail when you tried to use it?

1	2	3	4	5
Always	Often	Sometimes	Seldom	Never

3. How easy was this equipment to use?

1	2	3	4	5
Very Hard	Fairly Hard	Moderately	Fairly Easy	Very Easy

B. Section II (Circle One)

1. Does the shampoo concentrate work satisfactorily? If no, explain. YES NO

_____

_____

1

Figure 9-B (Cont)

(Circle One)

2. Does the machine produce proper quantities of foam? Explain. YES NO
_____
_____

3. When using the shampooer does the carpet become too wet? _____ YES NO
_____

4. How long does the carpeting take to dry after shampooing? _____
_____

5. Can the brush pressure be adjusted easily and satisfactorily? If no, explain. _____ YES NO
_____

6. Does the handle lock in the 45-degree and vertical positions? If no, explain. _____ YES NO
_____

7. Does the shampooer propel itself satisfactorily? Is it easy to maneuver? If no, explain. _____ YES NO
_____

8. Can you reach all areas of the carpeting satisfactorily? If no, explain. YES NO
_____
_____

9. Can the shampooer be transported to all required spaces without problems? If no, explain. _____ YES NO
_____

10. Is the equipment easy to set up, break down, clean, and stow? If no, explain. YES NO
_____
_____

11. Is the equipment worth using in order to save time or labor? (Consider what is required to set it up or tear it down.) If no, explain. _____ YES NO
_____
_____

Figure 9-B (Cont)

(Circle One)

12. Can you easily operate the shampooer while the ship is underway? If no, explain. _____ YES NO

13. Is operation of the shampooer easy to learn? If no, please comment. _____ YES NO

14. Is the operations manual satisfactory? If no, please comment. _____ YES NO

C. Section III

1. What other problems in using the equipment have you experienced?

2. What features of the equipment do you especially like?

Figure 9-B (Cont)

Instructions:

This questionnaire has been prepared to collect information from you on facilities maintenance equipment that is being used in the Facilities Maintenance Study. Your answers will be held in strict confidence by the facilities maintenance study group and will not have any effect on your present shipboard assignment, your qualifications for advancement, or your Navy career.

This questionnaire has three sections:

1. In the first section you are asked to rate some aspects of the FM equipment.

2. In the second section you are asked questions about specific features of the FM equipment.

3. In the third section you are asked to give any additional information that may be helpful to the study team.

Feel free to ask questions at any time.

Figure 10-B
FM Equipment Questionnaire on
Rotary Peening Equipment

Data Sheet D-5

FM Equipment Questionnaire
on

Rotary Peening Equipment

I. General Information

Ship: _____ Name: _____

Date: _____ Rate/Rating: _____

Interviewer: _____ Primary Duty: _____

Division: _____

What kind of training have you received on this equipment?

Contractor _____ OJT _____ Module _____

How often have you used this equipment? Very Little __ Some __ A Lot __

II. Rotary Peening Equipment Questionnaire

A. Section I (Circle your rating choice)

1. How well did each of the rotary peening devices do its job?

	Very Poorly	Fairly Poorly	Satis-fact.	Fairly Well	Very Well
a. Descobrader - floor model	1	2	3	4	5
b. Descobrader - portable	1	2	3	4	5
c. Dynascaler - portable	1	2	3	4	5

2. How often did each of the rotary peening devices fail when you tried to use it?

	Always	Often	Sometimes	Seldom	Never
a. Descobrader - floor model	1	2	3	4	5
b. Descobrader - portable	1	2	3	4	5
c. Dynascaler -	1	2	3	4	5

Figure 10-B (Cont)

3. How easy were each of the rotary peening devices to use for surface preparation?

	Very Hard	Fairly Hard	Moderately	Fairly Easy	Very Easy
a. Descobrader - floor model	1	2	3	4	5
b. Descobrader - portable	1	2	3	4	5
c. Dynascaler - portable	1	2	3	4	5

B. Section II (Circle One)

1. Do the flap assemblies wear satisfactorily? YES NO
If no, explain. _____

2. Are the flaps easy to install? If no, explain YES NO
_____

3. Is the handle on the floor model satisfactory? If no, why? YES NO
_____

4. Is the adjustment lever weight of the floor model satisfactory? If no, explain. YES NO
_____

5. Is the self propelling feature of the floor model satisfactory? If no, explain. YES NO
_____

6. Does the rotary peening device work satisfactorily with the available air pressure? If no, explain YES NO
_____

7. Is the portable model's present height satisfactory? If no, explain. YES NO
_____

8. Is the equipment easy to set up, break down, clean and stow? If no, explain specific problems. YES NO
_____

9. Is the equipment worth using in order to save time or labor? (Consider what is required to set it up or tear it down.) If no, explain. YES NO
_____

Figure 10-B (Cont)

(Circle One)

10. Can you easily operate this equipment while the ship is underway? If no, explain. _____ YES NO

_____

11. Is the operation of the system easy to learn? If no, please comment. _____ YES NO

_____

12. Is the operations manual satisfactory? If no, please comment YES NO comment. _____

_____

Section III

1. In considering the major parts of the equipment - the air motor, the rotating assembly, the air filter/lubricator/ regulator, and the hoses - what problems have you found in operating the equipment?

2. What features of the equipment do you especially like?

Figure 10-B (Cont)

Instructions:

This questionnaire has been prepared to collect information from you on facilities maintenance equipment that is being used in the Facilities Maintenance Study. Your answers will be held in strict confidence by the facilities maintenance study group and will not have any effect on your present shipboard assignment, your qualifications for advancement, or your Navy career.

This questionnaire has three sections:

1. In the first section you are asked to rate some aspects of the FM equipment.

2. In the second section you are asked questions about specific features of the FM equipment.

3. In the third section you are asked to give any additional information that may be helpful to the study team.

Feel free to ask questions at any time.

Figure 11-B
FM Equipment Questionnaire on Rotary Deck
Cleaning and Finishing Machine

FM Equipment Questionnaire
on
Rotary Deck Cleaning and Finishing Machine

I. General Information

Ship: _____ Name: _____

Date: _____ Rate/Rating: _____

Interviewer: _____ Primary Duty: _____

Division: _____

What kind of training have you received on this equipment?

Contractor _____ OJT _____ Module _____

How often have you used this equipment? Very Little __ Some __ A Lot __

II. Rotary Deck Cleaning and Finishing Machine Questionnaire

A. Section I (Circle your rating choice)

1. How well did the two speed rotary deck machine clean and finish deck surfaces?

1	2	3	4	5
Very Poorly	Fairly Poorly	Satis-factorily	Fairly Well	Very Well

2. Using the same scale as above, rate how well did the rotary deck machine clean and finish deck surfaces in the following ways?

a. Spray buffing (white pad)	1	2	3	4	5
b. Scrubbing (blue pad).	1	2	3	4	5
c. Wet stripping (brown pad).	1	2	3	4	5
d. Dry stripping (spray & brown pad).	1	2	3	4	5

3. How often did the rotary deck machine fail when you tried to use it?

1	2	3	4	5
Always	Often	Sometimes	Seldom	Never

Figure 11-B (Cont)

4. How easy was the rotary deck machine to use for deck surface cleaning and finishing?

1	2	3	4	5
Very Hard	Fairly Hard	Moderately	Fairly Easy	Very Easy

B. Section II

Circle One

1. Is the spray attachment effective? If no, If no, why? _____ YES NO

2. Does the safety switch work satisfactorily? If no, explain. _____ YES NO

3. Are the pads easy to install? If no, explain. _____ YES NO

4. Is it helpful to have two speeds? Why? _____ YES NO

5. Does the equipment work equally well on either resilient (vinyl asbestos tile, etc) or non-resilient (terrazo, painted, etc) deck surfaces? Explain. _____ YES NO

6. Can the machine be used in all areas satisfactorily? Explain. _____ YES NO

7. Is the equipment easy to set up, break down, clean, and stow? If no, explain specific problems. _____ YES NO

8. Is the equipment worth using in order to save time or labor? (Consider what is required to set it up or tear it down.) If no, explain. _____ YES NO

9. Can you easily operate this equipment while the ship is underway? If no, explain. _____ YES NO

10. Is the operation of the system easy to learn? If no, please comment. _____ YES NO

11. Is the operations manual satisfactory? If no, please comment. _____ YES NO

Figure 11-B (Cont)

C. Section III

1. What other problems in using this equipment have you found? Please relate this information to the type of equipment, to the type of operation, and to the type of deck surface.

2. What features of this equipment do you especially like?

Figure 11-B (Cont)

General Data Collection Instructions

The purpose of these instructions is to provide a guide for data takers, assigned to this program, in filling out the data sheets. Data takers must familiarize themselves fully with all pertinent methods, forms, and analysis techniques prior to collection of data aboard ship.

Instructions

A substantial amount of data to be collected in this study is subjective, e.g., opinions as to equipment/material effectiveness, judgments on cleanliness, condition and appearance, attitudes toward training programs, etc. Data collectors in conducting interviews with ship's personnel must be sensitive to the fact that results or responses can be affected by the attitudes of the interviewer. Data collectors therefore should appear neutral and objective at all times during interactions with ship's personnel. Uniformity of interaction between the data taker and personnel aboard different ships is a major goal of data collection. Discussion about other ships in the program is not to occur during interview or testing sessions.

The following guidance should also be followed:

- If asked a question, answer only with the required information. If possible, cite the source to which the inquirer may refer.
- Never give advice.
- Record all questions and your answers to them.
- Record unusual testing circumstances.
- Do not interfere with ship's routine in any way.
- Immediately contact Test Director for instructions if in doubt as to how to handle a particularly unusual situation.
- Follow the detailed instructions on data collection forms as precisely as possible. If instructions could not be followed, record the circumstances and contact the Test Director for further guidance. Ensure that all labeling information for each form is filled out.
- Keep a time oriented log of your activities during every ship visit. The record must be legible and complete.
- Carry all supplies (forms, pencils, instructions) you will need; do not ask ship personnel for provisions of any kind.

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